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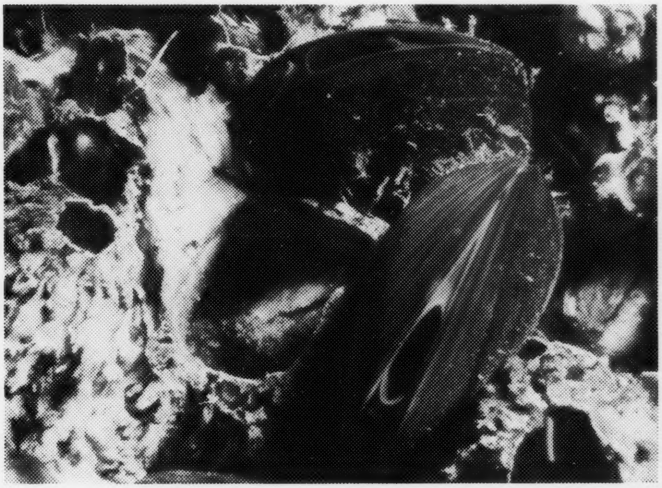

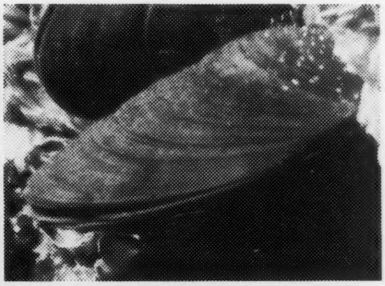

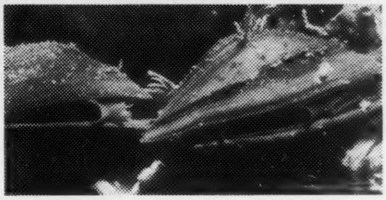

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MFR PAPER 1318

An Analysis of the Charter Boat Fishing Industry on the Texas Gulf Coast

ROBERT B. DITTON, RICHARD N. JARMAN, and STEVE A. WOODS

ABSTRACT—This paper examines the nature, extent, and characteristics of the Texas Gulf Coast charter boat fishing industry and its implications for fisheries management. Personal interviews were completed with 41 of the 88 Texas Gulf Coast charter operators in business during 1975. Data were obtained regarding charter operators: Characteristics, business structure, charter fishing activities, and economic returns. This study revealed that the Texas charter industry lacks a formal industry organization, is composed of small independent businesses which yield insufficient incomes to keep operators in business full time, involves operators who are primarily concered with the life-style afforded by charter fishing, and is an integral part of the State's tourism industry.

INTRODUCTION

Assessing the varied demands on marine fisheries resources is one of the most difficult tasks confronting fisheries managers. Historically, emphasis has been placed on the commercial use of fisheries resources. As a result, much of the available data concerning the biological, economic, and social impacts of fisheries utilization pertain to commercial fishing industries. In recent years, however, increased recognition has been given to the impacts of marine recreational fishing. Deuel (1973) has pointed out that in terms of the number of saltwater sport fishermen and the size of the recreational catch, marine recreational fishing can no longer be considered an inconsequential use of the nation's fisheries resources.

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The economic impact of marine recreational fishing has also reached substantial proportions. The total retail sales of goods and services associated with marine recreational fishing were estimated to be $1,333 million in 1972. These sales generated an estimated $510 million of value added and $285 million in wages and salaries in business sectors where direct spending took place. In 1975 sport fishing consumers purchased an estimated $1,840 million worth of goods and services at the retail level. These sales generated approximately $699 million of value added and $343 million in related wages and salaries (Centaur Management Consultants, Inc.[1]).

[1]Centaur Management Consultants, Inc. 1977. Economic activity associated with marine recreational fishing. Draft report. Centaur Management Consultants, Inc., Washington, D.C.

Aside from national and regional trends and averages of sport fishing activity and expenditures, however, decision-makers often lack sufficient information, particularly in state and local situations, for considering the impacts of recreational fishing in the development of marine fisheries management policies and regulations.

Popular arguments contrasting recreational and commercial fishing often portray both fisheries as big business. Recreational fishing is characterized as a social luxury associated with fisheries conservation, while commercial fishing is characterized as an economic necessity associated with fisheries exploitation (Carlton, 1975). Generalized statements concerning either recreational or commercial fishing, however, provide a weak base for making fisheries resource allocation and management decisions. If fisheries management is to reflect economic, social, and resource concerns as directed by the U.S. Fisheries Conservation and Management Act of 1976 (Public Law 94-265), research is needed to develop a comprehensive data base for evaluating both commercial and recreational demands.

Although recreational fishing is often viewed as a homogeneous activity, a number of distinct components or fishing sectors can be identified. Along the Texas Gulf Coast recreational fishing can be grouped into three broad types: Onshore or nearshore fishing, bay fishing, and offshore or Gulf fishing. This paper is concerned with an industry which provides a means for bay and Gulf fishing: the Texas charter fishing industry.

In 1970, an estimated 15 percent of the sport fishermen in the entire Gulf Region used a charter or party boat at least once, spending over $20 million in charter fees alone (Bureau of Sport Fisheries and Wildlife, 1972). Several area-specific studies indicated charter operations can have substantial economic impact on local communities and contribute substantially to the total recreational economy in an area. In a study of the Wisconsin charter fishing industry, Ditton et al. (1975) found

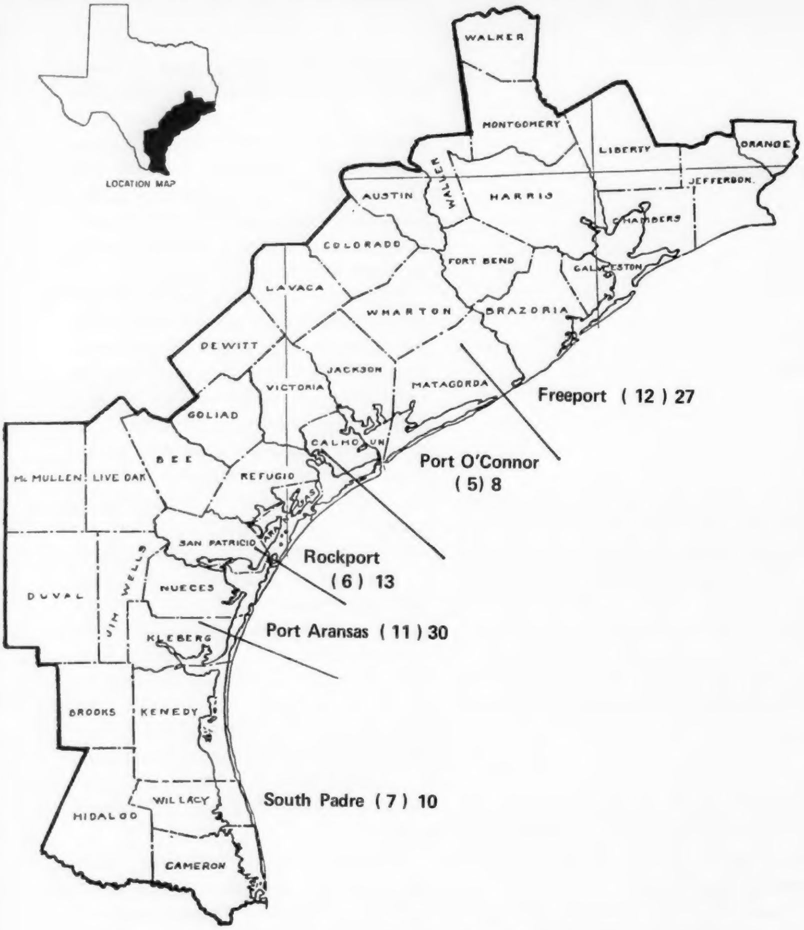

Figure 1.—Regional distribution of Texas Gulf coast charter businesses operating in 1975: Sample and size population.

charter businesses had a sizable economic impact on shoreline communities with a total statewide economic impact of approximately $4 million. In Choctawatchee Bay, Fla., and its adjacent Gulf of Mexico waters, charter and party boat fishing accounted for 69 percent of the sport fishing effort and 75 percent of the sport fishing catch during approximately a 1-year period (Irby, 1974).

During the summer of 1974, an extensive literature review and interviews with representatives from various government agencies and private organizations familiar with saltwater sport fishing in Texas revealed an absence of information concerning the Texas Gulf Coast charter industry (Ditton and Jarman[2]). Even the basic parameters of the Texas charter fishing industry, such as the number and location of charter operations, had not been identified. This paper presents the findings of a study conducted to identify and to understand the Texas charter boat fishing industry and discusses possible management implications.

METHODS

An inventory of Texas charter boat fishing businesses was compiled from U.S. Coast Guard vessel documentation records, consultation with area marine extension agents, local chambers of commerce, marina operators, telephone books, newspapers, and promotional literature obtained from coastal communities. Owners of Texas coastal charter fishing businesses in operation during all of 1975 were contacted. Operators who had retired from charter fishing before 1975 or had begun charter fishing during 1975 were excluded. A study population of 88 businesses was identified.

Based on the geographic distribution of the 88 businesses, the Texas coast was divided into five regions. A 50 percent random sample of the businesses in each region was drawn. During the data collection period from March through May 1976, efforts were made to contact the charter boat owners to schedule an interview. If an interview could not be scheduled after four attempts, the operator's name was removed from the sample and another one was randomly selected. Using a structured interview schedule adapted from that used by Ditton et al. (1975), 41 personal interviews were completed. Figure 1 shows the distribution of the 88 business operating during 1975 and the number of interviews (in parentheses) completed in each region. Data were collected to describe charter operators, their activities, resources, business structure, business revenue, and expenditures.

FINDINGS

Industry Organization

Responses to questions concerning membership in state or local chapter fishing organizations revealed that the Texas charter fishing industry is not formally structured. No respondents reported membership in or awareness of a statewide charter fishing association. Only one local charter organiza-

[2]Ditton, R. B., and R. Jarman. 1974. Development of a sport fishing focus in the TAMU Sea Grant Program - a program statement. Proposal prepared for the Texas A&M Sea Grant Program, College Station, 46 p.

tion, the Port Aransas Boatman's Association, was identified. Eighty-two percent of the operators interviewed in the Port Aransas area belonged to the association. Several of its members indicated a decline in recent years in the effectiveness of the association as a standard setting and enforcing entity.

Only 27 percent of the operators belonged to local chambers of commerce. When asked what services were provided, 64 percent of the operators belonging to a chamber of commerce said they were mentioned in brochures and 36 percent said they received referrals. Eighteen percent of those operators belonging to a chamber of commerce reported they received no support.

Although little formal organization was found, there appears to be a substantial degree of informal inter- and intra-industry organization. Sixty-eight percent of the operators reported other local charter operators and businesses referred customers to them, and 66 percent said they referred customers to other local operators and businesses. Twenty-five percent reported paying commissions for booking, but none reported receiving commissions for referrals.

The Texas Charter Boat Operator

The majority of charter operators interviewed engaged in charter fishing on a part-time basis. Twenty-seven of the 41 fishermen were employed in other occupations either concurrently or during part of the year. Fourteen fishermen said charter fishing was currently their only occupation. Of the 14, 11 were retired from other occupations, one had made a career of charter fishing and two were unemployed and looking for work. Present and past occupations of the charter operators included: Civil servant, auto mechanic, police officer, dentist, oil executive, motel owner, musician, military officer, and commercial fisherman. Only one said he had been involved with charter fishing during his entire working career.

Thirty-nine charter operators responded to the question, "What percent of your income is derived from charter fishing?" Charter fishing income averaged 41.3 percent of the total income of the responding operators while charter fishing accounted for an average of 61.5 percent of the working time of the 41 operators interviewed. Although there appears to be a substantial difference between the percentage of total income derived from charter fishing compared to the percentage of total working time devoted to charter fishing, the difference is due primarily to the number of operators who were retired from other occupations. Adjusting for the operators who were retired from other occupations results in an average of 39.8 percent of the operators' total income attributable to charter fishing and an average of 41.9 percent of working time.

Although the discrepancy between the amount of income and the amount of working time may suggest the respondents are not following sound business procedures, the majority said they had not entered the charter fishing business for economic reasons. When respondents were asked what led them to become charter operators, only 10 percent said money was the main reason. Thirty-seven percent of the respondents referred to their enjoyment of fishing; 24 percent said their charter fishing business began as a hobby; and the remaining 29 percent referred to the opportunity to live in a particular community, the enjoyment of boating, and the involvement of friends or relatives with charter fishing. Most of the reasons given were noneconomic. Many respondents volunteered that monetary returns of operating a charter boat were often a discouraging rather than an encouraging aspect of the business.

Respondents reported operating a charter fishing business on the Texas coast for an average of 11.5 years. This contrasts sharply with studies of other charter fishing industries. Wisconsin (Lake Michigan) charter operators had been in business an average of only 3.8 years (Ditton et al., 1975) and more than half of the Georgia (Atlantic) charter operators had been in business less than 3 years (Brown and Holemo, 1975). The relatively long history of the respondents' charter fishing involvement suggests charter fishing is a well-established industry on the Texas coast. Also the length of time the respondents operated a charter business indicates they are experienced charter operators and have apparently received sufficient economic and noneconomic benefits to remain in business.

The charter operators have operated from their current home port for an average of 10.5 years. The respondents said they do not shift ports in response to fish migrations or seasonal weather changes. Only one operator reported regularly changing ports during the year in response to customer demand.

Business Characteristics

Of the 41 businesses surveyed, 34 were single proprietorships, 4 were partnerships, and 3 were corporations. Thirty-five of the businesses had only one vessel, three businesses had two vessels, and three businesses had three vessels—making a 50-boat charter fishing fleet.

The average length of the vessels is 30.6 feet with an average gross weight of 8.6 tons. Respondents estimated the current market value of their vessels at an average (single vessel) value of $16,826. The majority of the vessels were equipped with a fathometer (78 percent) and a VHF or CB radio (96 percent). Twenty-eight percent of the vessels were equipped with a fish finder and 28 percent with loran. Only four percent had no electronic equipment. Even though many of the vessels had some electronic equipment for selecting a fishing site, the majority of the operators said the equipment was used infrequently. Experience was reported as the key factor in selected fishing sites.

There are numerous differences in vessel length, boat market value, and party size when charter operations are viewed on the basis of where they usually take people fishing: bay only, Gulf only, and a bay/Gulf combination. Bay boats averaged 24 feet in length, had a net boat value of $9,265, and generally

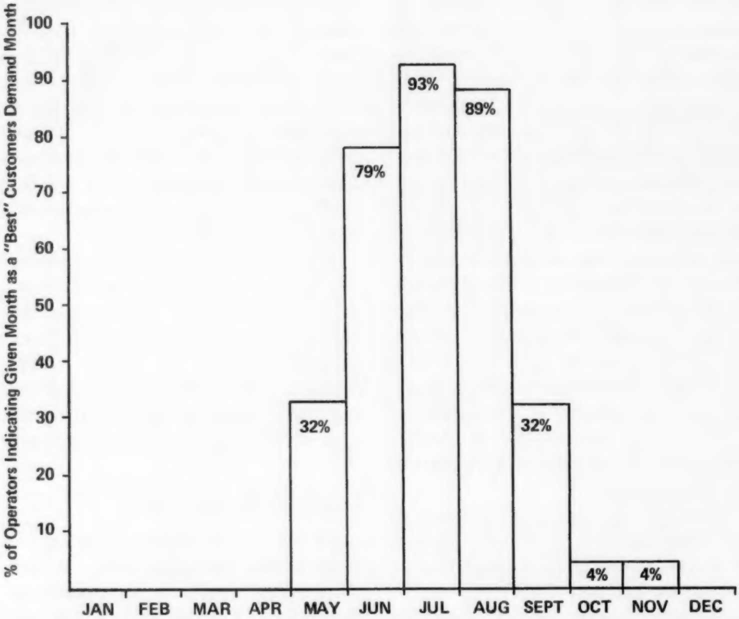

Figure 2.—Distribution of respondents by reported "best" customer demand months.

carried 3-4 customers. Gulf boats averaged 34 feet in length, had a net boat value of $22,232, and generally carried 4-6 customers. Boats used for fishing both bay and Gulf were more like bay boats with an average length of 27 feet and a net boat value of $10,331. Thirty of the vessels were each operated by a captain and one crew member (generally Gulf boats), and 20 vessels were each operated with only a captain (generally bay boats).

Charter Fishing Activities

The price of a charter fishing trip varied considerably among the 41 businesses represented in the study. The factors influencing the price structure were: Number of fishermen in a party, type of vessel, length (in hours) of a trip, and the type of trip (either bay or Gulf fishing). Assuming a four person party, the charter fee ranged from approximately $25 to $75 per person with Gulf charters the most costly. The price of a charter trip is intended to cover the use of the charter vessel and the experience of the vessel's captain. For the majority of the businesses, the owner was also the captain. The fee also included fishing instructions. Sixty percent of the respondents reported the base rate included the provision of bait, and 56 percent reported the provision of tackle.

Sixty-three percent of the respondents said their vessels were available for charter all year. However, May through September were the months of highest demand with July the best month (Fig. 2). The charter operators' season or period of greatest activity corresponds roughly with the ending and beginning of the school year.

Surprisingly few operators used their vessels for activities such as scuba charters, carrying oil rig crews, or private use to increase their earnings.

The 41 respondents reported providing charter services to 16,648 fishermen in 1975. If each of the 50 vessels owned by the respondents was used equally, the average number of fishermen carried during 1975 would be 333 per boat. However, three of the owners of multiple boat businesses did not have a captain for each vessel. At any one time, only 46 charter vessels could be used. Based on the total of 46 vessels capable of being used, the average number of fishermen carried during 1975 increases to 362 per boat. Although many of the charter vessels were licensed to carry a maximum of six passengers plus the captain and crewmember, operators indicated an average of four fishermen were carried on each charter.

As discussed, the respondents provided charter service to both bay and Gulf waters. To obtain information which may aid in the siting of artificial reefs, operators were asked to indicate the average one-way distances traveled during a bay and Gulf charter. The one-way distance traveled to a fishing site in bay waters ranged from 4 to 26 miles with over 50 percent of the operators traveling less than 10 miles. For Gulf fishing, the one-way distance traveled ranged from 5 to 50 miles with over 50 percent of the operators traveling less than 20 miles. Based on the number of charters in bay and Gulf waters, 24 percent of the operators chartered primarily to bay waters, 56 percent chartered primarily to Gulf waters, and 20 percent chartered approximately equally to bay and Gulf waters.

Respondents were asked to identify the principal target species of their charter fishing efforts (Table 1). Few

Table 1.—"Primary species sought" as reported by operators.

Species	Operators reporting (%)
Kingfish	78
Spotted seatrout	44
Red drum	39
Ling	32
Red snapper	27
Dolphin	15
Warsaw	12
Bonito	12
Sailfish	12
Grouper	7
Flounder	7
Jackfish	7
Tarpon	7
Tuna	5
Marlin	2

operators reported only one target species. Freeport, Tex., operators fished primarily for king mackerel, *Scomberomorus cavalla*, from May to September and red snapper, *Lutjanus campechanus*, during the remaining months. The Rockport and Port O'Connor, Tex., operators fished primarily for spotted seatrout, *Cynoscion nebulosus*, and red drum, *Sciaenops ocellata*. Port Aransas operators fishered for king mackerel, *Scomberomorus cavalla*, with some spotted seatrout and red snapper, *Lutjanus campechanus*, fishing in the spring, fall, and winter months. Charter operators in the South Padre region fished for a variety of species including red drum, spotted seatrout, tarpon, *Megalops atlantica*, sailfish, *Istiophorus platypterus*, red snapper, and grouper, *Epinephelus* spp., and *Mycteroperca* spp.

Charter Fishing Financial Information

Data were obtained on the fixed and variable expenses associated with the operation of charter vessels during 1975. For multiple businesses, expense data was obtained for each vessel. A comprehensive cost accounting form was used to insure the identification of the expenses incurred during 1975 with the exception of interest payments and income taxes. A revenue total for each vessel was calculated based on the number and type of fishing trips taken during 1975 and the cost of these trips based on the average number of customers each operator took fishing.

For the purposes of the financial analysis, three multiple-boat businesses which involved the use of only one boat at a time were considered single vessel operations. In these three cases, all revenue and expenditures associated with each vessel were attributed to a single hypothetical vessel. In essence, the revenues and costs incurred by these businesses were similar to the revenues and costs incurred by a single boat business. The per boat economic analysis was therefore based on 46 rather than 50 boats.

Table 2.—Pretax profitability per boat ($n=46$) in dollars.

Total	A[1] Total reported by operators	B[2] Total divided by no. of respondents	C[3] No. of respondents divided by total no. of boats	D[4] Total divided by total no. of boats	E[5] % of exp. to total exp. in col. D
Income	$621,169.00	$13,503.67	46/46	$13,503.67	
Expenses					
Fixed					
Insurance	$ 25,387.00	$ 875.41	29/46	$ 551.89	7.2
Advertising	5,791.00	206.82	28/46	125.89	1.6
Dock fees	24,740.00	634.36	39/46	537.83	7.0
Office rent	2,800.00	560.00	5/46	60.87	0.8
Local taxes	1,515.00	252.50	6/46	32.93	0.4
Depreciation	44,364.00	2,464.67	18/46	964.44	12.5
Total		$ 4,993.76		$ 2,273.85	29.5
Variable					
Commissions paid	$ 1,527.00	$ 305.40.	5/46	$ 33.20	0.4
Repairs	53,277.00	1,566.97	34/46	1,158.20	15.0
Fuel	78,370.00	1,703.70	46/46	1,703.70	22.1
Wages	66,958.00	2,911.22	23/46	1,455.61	18.9
Bait	20,476.00	819.04	25/46	445.13	5.8
Tackle	16,328.00	510.25	32/46	354.96	4.6
Ice	4,795.00	228.33	21/46	104.24	1.4
Other	7,835.00	1,305.83	6/46	170.33	2.2
Total		$ 9,350.74		$ 5,425.37	70.4
Total expenses		$14,344.50		$ 7,699.22	
Net profit (loss) before interest and taxes		(840.83)		$ 5,804.45	

[1]Column A is the sum of all responses for each item.
[2]Column B is the total amount for a given item (Column A) divided by the number of boats incurring that expense (numerator of Column C).
[3]Column C is the number of boats incurring an expense divided by the total number of boats. For example, the total insurance expense incurred by all operators was $25,387. Twenty-nine of the forty-six boats, 65.2 percent, incurred an insurance expense. The average premium for the twenty-nine boats was $25,387/29 or $875.41.
[4]Multiplying Column B by Column C gives Column D, the Total Expenditure figure divided by the total number of boats. Subtracting the expenses from the income in Column D gives the average net pretax and interest profit per boat.
[5]Column E shows the percentage an expense item is to the total expenses. This column should be viewed cautiously because charter operators simply approach their business differently. Several operators paid their dockage fees on a commission basis. Others paid higher dock fees but received free bookings, bait, and/or ice. Some value judgments were necessary to determine which category best fit the expense figure given by the operator.

Based on these 46 vessels, the average profit in 1975 was $5,804 per boat (Column D, Table 2). This represents the average net profit before any interest payments and income taxes. Variable expenses (repairs, fuel, wages, bait, and tackle) accounted for approximately 70 percent of the total expenses associated with the operation of a Texas Gulf Coast charter boat in 1975. If the owner of a hypothetical average charter vessel had incurred the average of each of the expenses reported, he would have lost $840.84 in 1975 (Column B, Table 2).

More detail on the profitability of operating a charter fishing vessel is shown in Table 3 where the net profits associated with vessels used for bay fishing, Gulf fishing, and a combination of bay/Gulf fishing are compared. In 1975, the 10 vessels used primarily for bay fishing returned an average net profit of $5,137 per boat; the 28 Gulf vessels average a net profit of $4,265 per boat; and the eight vessels used for both bay and Gulf fishing averaged a net profit of $12,317 per boat. Using the reported value of the charter vessels as a measure of the initial investment needed to begin a given type of charter operation, the initial investment is greatest for Gulf-only operations followed by combination bay/Gulf operations and bay-only operations.

DISCUSSION

This paper provides a perspective on the dynamics of the Texas charter fishing industry which should be useful to fisheries managers. If the Gulf Regional Fishery Management Council identifies charter fishing as a managerially important fishery, an understanding of the nature and characteristics of

the charter industry throughout the Gulf region will be necessary to determine if and how particular fisheries resources will be allocated to this fishing sector.

Regional differences in charter fishing catch and effort may require that measures like catch quotas or season limits (if considered at all) be specifically designed for particular areas or States within the region. Different solutions may be needed because Texas and Florida charter industries, for example, may be different in terms of the scale of the businesses involved, operating season, and the magnitude and composition of catch.

Practically no information is available on the size and composition of the Texas charter fishing catch. Although a creel survey has been conducted in several Texas bay systems (Heffernan et al., 1976), data specific to charter boats have been collected at only one location, and no catch data have been collected for offshore Gulf charter fishing. Identification of the charter fishing catch, however, is important to determine if catch limits are necessary. Besides harvest concerns, the Fishery Conservation and Management Act directs the Regional Councils to consider economic and social matters.

This study indicates that the Texas charter fishing industry is made up of small independent businesses which operate at moderate to high profit margins but which do not yield sufficient cash to keep a large number of operators in business full time. This may be due in part to the relatively short charter fishing season, as determined by customer demand for charter fishing on the Texas coast. Although the industry lacks formal organization at the State and local level, there is a substantial degree of informal organization in local communities as evidenced by customer referrals among operators and related businesses. It appears that the Texas charter industry has developed more as a result of the life style which charter fishing affords than solely out of any monetary benefits which may accrue to its members.

Table 3.—Comparative financial data by type of charter fishing operator.

Item	Bay only	Gulf only	Bay/Gulf combination
No. of boats	10	28	8
Income	$8,454.60	$14,251.46	$17,198.13
Expenses			
Fixed			
Insurance	130.20	757.32	210.00
Advertising	41.50	148.21	153.31
Dock fees	270.40	574.21	661.25
Office rent	5.00	98.21	0.00
Local taxes	102.50	14.82	6.25
Depreciation	662.00	1,240.86	375.00
Total	$1,211.60	$ 2,833.63	$ 1,405.81
Variable			
Commissions (pd.)	89.70	0.00	78.75
Repairs	602,30	1,439.43	868.75
Fuel	1,089.10	2,055.32	1,241.25
Wages	71.00	2,366.00	0.00
Bait	109.50	515.39	606.25
Tackle	116.80	384.64	506.25
Ice	23.90	113.39	173.88
Other	3.50	278.57	0.00
Total	$2,105.80	$ 7,152.74	$ 3,475.13
Total (all expenses)	$3,317.40	$ 9,986.37	$ 4,880.94
Net profit before interest and taxes	$5,137.20	$ 4,265.09	$12,317.19
Total boat value	$9,555.00	$25,554.00	$11,112.00
Trips	115.70	68.00	134.12
Pretax profit[1] margin per trip	54.87	104.39	102.32
Trips required to[2] break even per year	22	28	14
Cash flow per year[3]	$5,799.20	$ 5,505.95	$12,692.19

[1] $\frac{\text{Income—total variable expenses}}{\text{trips}}$.

[2] $\frac{\text{Fixed expenses}}{\text{Pretax profit margin per trip}}$.

[3] Net profit before interest and taxes plus depreciation.

Although the exact relationship of charter fishing and coastal tourism was not specifically determined in this study, the degree of informal cooperation between the charter industry and other tourism elements like hotels, restaurants, and sport shops suggests the charter industry is an integral part of coastal tourism, particularly in small communities.

Study findings suggest several points which will require consideration in the formulation of any management regulations for the Texas charter fishing industry. There is the basic question of how the charter fishing industry should be viewed in the context of fisheries management. Should charter fishing be managed as a commercial or recreational fishing industry? Since the Texas charter boat operators receive economic benefits from the utilization of common property fisheries resources, the industry may be, and often is in many areas, viewed as a form of commercial fishing. However, the methods and techniques of charter fishing are indistinguishable from those of the recreational fisherman who is able to purchase and use his own vessel. The Texas charter fishing industry can therefore be viewed as a recreational service industry which provides fishermen with a means of access (for a fee) to fisheries resources.

How the charter fishing industry is regulated may have a direct influence on the industry's viability. It is difficult to determine what the impact of catch quotas and other regulations would be on the industry. Since the economic viability of the industry is partially related to customer demand, the imposition of quotas on the number, size, or species of fish which may be taken may or may not act to discourage this demand. Other management measures such as designating a charter fishing season or controlling the number of charters an operator can take are more easily related to the industry's viability. For example, the Texas charter fishing season was found to be essentially 5 months when charter businesses received the bulk of their revenue. Reducing the season or the number of charters an operator could take by regulation could be critical to some operators. The marginal operators would be unable to compete and would be forced out of the industry. Although charter operators indicated monetary benefits were not a primary motive for their involvement in the industry, it is unlikely that most would continue to operate if confronted with no chance of economic gain or certain economic loss.

Another important factor is the magnitude of the variable operating expenses. As noted, approximately 70

percent of the operating expenses incurred by respondents during 1975 were variable costs. Rising fuel costs combined with a limited season again will surely force some operators out of business. This will reduce the economic benefits which accrue to local communities as a result of charter operations.

This study also points to the need for a mechanism for monitoring changes in the size and distribution of the Texas charter boat fishing industry. Due to the absence of a continuous licensing or registration system to identify members of the Texas charter fishing industry, this study was limited to a single study year. To consider the continuing impacts of the charter industry, it is important that managers be able to identify whether the industry is growing or declining by location. This could be easily achieved by altering the current Texas guide license so that charter fishing operators could be differentiated from the variety of activities presently covered by the guide license.

ACKNOWLEDGMENTS

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MFR PAPER 1319

Characteristics, Participation, and Motivations of Texas Charter Boat Fishermen

ROBERT B. DITTON, THOMAS J. MERTENS, and MARTIN P. SCHWARTZ

ABSTRACT—The characteristics and motivation of Texas charter boat fishermen are identified in this paper. Profiles were compiled for the following: 1) The sociodemographic characteristics of place and residence, age, income, and occupation of charter fishermen; 2) their participation in charter fishing; 3) reasons for participating in charter fishing; and 4) opinions about their charter fishing experiences. This information is provided as a useful input to local and regional decision makers and also to clarify some of the issues involved in defining a "total" fishing experience. Thirteen motives, indicative of some of the reasons fishermen go charter fishing, were identified using factor analysis. Study findings indicate that fishermen consider many things important to a successful trip in addition to catching fish. Study findings are discussed, and implications and future research directions are suggested.

INTRODUCTION

Traditionally, fisheries management operates under the notion that sport fishermen are only interested in catching fish and therefore, if a fisherman does not catch anything, he has not had a successful experience. This philosophy tends to classify the fisherman solely as a consumer of a natural resource. As a result, fishery managers concentrate on the number of fish available and the number of fish caught. The nonconsumptive aspects of fishing are not widely being reflected in conventional approaches to fisheries management. Greater efforts need to be made to identify and to manage for the "total" fishing experience.

Data has been gathered and reported by Federal agencies (Bureau of Sport Fisheries and Wildlife, 1972; Deuel, 1973) to provide an understanding of how many Americans fish, their socioeconomic description, and their fishing-related expenditures. Most national surveys appear to be based on the assumption that fishermen are a homogeneous lot because they only present broad trends and averages related to fishing activity. The result is that State, regional, and local officials wishing to "break out" data relevant to their unique situations or particular concerns are left with insufficient sample sizes if they are able to disaggregate the data at all. Also, generalizations based on national descriptive profiles of fishermen and related expenditures are of little utility to governmental decision makers when dealing with particular groups of fishermen, a particular location, or a particular fishery. Studies are needed which identify and evaluate resource requirements of subgroups of specific fishing populations. This approach to the study of fishermen will reveal that fishing populations are diverse, both in terms of their characteristics and their respective resource requirements. The identification of subgroups and their related resource requirements will enable decision makers to better understand the interests involved, the consequential effects of their decisions, and the effects of segments of fishing populations on fisheries.

Social research has begun to deal with problems inherent in understanding and providing useful information relative to the interrelationships of users and particular spatial or physical resources. One such direction has identified factors other than the fish component (biological stock maintenance) that describe nonconsumptive recreational aspects of sport fishing (Ballas et al.[1]; Field[2]; Bryan, 1976; Driver and Knopf, 1976; Graefe and Ditton, 1976). A major recurring topic of this research has dealt with the assumed needs of fishermen to catch fish. Further research needs to be directed at understanding the importance of catching fish in relation to all the other possible reasons for fishing.

Knowledge of fishermen's motivations can give resource decision makers an additional tool for determining whether the type of experience being provided is satisfactory. Comprehensive decision making should attempt to integrate both biological and social understanding. This is required in fisheries management as carried out under the Fishery Conservation and Management Act (P.L. 94-265). This approach has been considered successful in other realms of natural resource

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[1]Ballas, J. A., C. J. Gilchrist, and A. S. Williams. 1974. Trout fishermen in the Gallatin Canyon: Motives and perspectives on quality. Paper presented at Annual Meeting of the American Fisheries Society, Honolulu, 8-11 Sept. 1974, 19 p.

[2]Field, D. R. 1974. Patterns of participation, characteristics and preferences of Puget Sound saltwater sport fishermen. Research proposal to State of Washington, Water Research Center, Seattle, 27 p.

decision making and planning like backcountry wilderness management (Ditton, 1977), and is long overdue in fisheries management.

This paper seeks to provide understanding of charter boat fishing in Texas. Charter fishermen were studied according to the two distinct areas where they fish: coastal bays and the open Gulf. By focusing on particular subgroups of the charter fishing population, a more specific understanding of the requirements of charter fishermen in Texas is achieved.

OBJECTIVES

The objectives of this study were to: 1) Define and identify a Texas charter boat fishing population; 2) describe Texas charter fishermen based on sociodemographic characteristics; 3) identify subgroups of the population based on variables which describe participation; 4) measure the relative importance of hypothesized reasons for participation; and 5) assess implications of findings for fisheries management decisions.

STUDY POPULATION

The population of interest is all individuals who utilize charter boats along the Texas Gulf Coast. Since this specialized group of fishermen is not conveniently available, a population which is accessible was defined to represent the total population of charter fishermen. The relatively large study area (the Texas Gulf Coast), the large number of charter operators (88) identified, and the relatively infrequent rate at which individuals participate in charter fishing, would have made it extremely difficult and costly to interview individual charter fishermen on site. As an alternative, a listing of names and addresses of charter fishermen was sought for sampling purposes.

A listing of charter boat fishermen was obtained from personal records maintained by the individual charter boat operators. A sample of 15 of 88 operators resulted in names and addresses of 810 charter fishermen. Inadequate address information rendered 31 percent of the provided names unusable for survey purposes. This left 559 charter fishermen in the sample frame. About 25 percent of the fishermen (141) were systematically selected for pretesting the survey instrument. The remaining 418 names constitued a sample of charter fishermen. Each fisherman was mailed a questionnaire in February 1977. One hundred ninety-one (46 percent) useable questionnaires were returned for analysis.

FINDINGS AND ANALYSIS

Sociodemographic Characteristics

Charter fishing on Texas' coast is an activity pursued by few out-of-state residents (2 percent). The majority of charter fishermen (64 percent) resided in one of the four largest urban centers of the State: Dallas-Fort Worth (23 percent), Houston (21 percent), San Antonio (14 percent), and Austin (6 percent). Excluding Harris County where Houston is located, only 4 percent of the charter fishermen resided in the counties bordering the Gulf of Mexico. The remaining 32 percent resided primarily in the east-central region of the State.

Most charter fishermen (74 percent) were between 30 and 59 years of age. The mean age was 45. However, this mean age actually represented only 1 percent of the survey sample. The age 30 was common and represented 5 percent of the total sample. Eleven percent of the sample were less than 30 years of age and 15 percent of the survey sample were older than 59. The youngest charter fisherman responding to the survey was 14 years of age; the oldest was 79.

Collectively, the age distribution of charter fishermen is considerably higher than the age distribution for all fishermen in general (Bureau of Sport Fisheries and Wildlife, 1972). The age distribution of charter fishermen in Texas closely parallels the age distribution of Wisconsin's Lake Michigan charter fishermen, reported by Ditton et al. (1975). Seventy-seven percent of the Texas fishermen and 73 percent of the Wisconsin fishermen were 35 years or older while only 45 percent of all U.S. fishermen were 35 years old or older. Unfortunately, studies from other regions do not provide descriptive information about charter fishermen which would enable broader generalization.

Compared to all fishermen in the U.S. (Bureau of Sport Fisheries and Wildlife, 1972), Texas charter fishermen have extremely high incomes. Seventy-eight percent of those Texas charter fishermen surveyed had incomes of about $20,000 per year. Further, 21 percent had incomes above $50,000 per year. The mean income of the entire survey sample was approximately $33,000. Medical doctors, business executives, sales representatives, technical engineers, business owners and managers, and general contractors were common occupations.

Recreational Fishing Backgrounds and Participation

All charter fishermen surveyed had recreational fishing backgrounds and nearly all (92 percent) were introduced to fishing in freshwater environments. Most charter fishermen (80 percent) had their first fishing experience before they were 12 years of age. They varied considerably in the number of times they went fishing during 1976. Fifty percent went fishing only six times or less during the year. Another 32 percent went fishing between 6 and 20 times and the remaining 18 percent made more than 20 outings during the year. The mean number of annual outings for the entire survey sample was 13.2 trips; of these, 3.2 were charter fishing trips. Fifty-seven percent of all charter trips taken were to coastal bays; the remaining 43 percent were trips to the deepwater Gulf. Most charter trips (54 percent) involved one day's fishing. Seventy-two percent of the charter fishermen surveyed always returned to the same coastal community for subsequent fishing trips.

Generally, the total amount of time devoted to fishing has remained about the same over time for the entire survey sample. Fifty-three percent indicated that their participation stayed the same over the years since they began fishing. Twenty-four percent indicated that their participation in fishing had increased and 23 percent indicated a decrease in participation since they began fishing. Although overall fishing time has remained somewhat constant for all the fishermen (those increasing were nearly equal to those decreasing), the type of fishing resources used, namely freshwater or saltwater, has changed.

Saltwater fishing participation has increased and participation in inland fishing has decreased for the charter fishing group under study.

Table 1.—Composition of charter fishing groups, 1976.

Group type	Percent of groups of this type
Family member only	27
Friends from work (colleagues)	13
Other friends	21
Businessmen entertaining clients	11
Combinations of above	28
Total	100

Table 2.—Distribution of group type over fishing locations, 1976.

Group type	n[1]	Gulf	Bay	Both	Total %
Family	89	39%	44%	17%	100
Friends	83	45%	45%	10%	100
Colleagues	51	55%	33%	12%	100
Clients	50	58%	30%	12%	100
Total survey sample	[2]273	49%	38%	13%	100

[1]The number in each group type was derived from the 191 respondents. The total is greater than 191 because some respondents made more than one trip during 1976. This reason for the greater than 191 total holds for Tables 3 through 6 also.

[2]The combined category which accounts for 28 percent of the charter fishing groups is excluded from Tables 2 through 6 since group composition is unclear. Totals do not reflect this category.

Types of Charter Fishing Groups

Participation in charter fishing can be characterized by the relationship of the persons in the charter fishing groups: Family members, friends from work (colleagues), friends not from work, businessmen entertaining their clients, or combinations of these four types (Table 1). Family groups were most prevalent. Of the groups composed of multiple relationship types (28 percent), family members were present in 66 percent.

Work-related groups (colleagues and business entertainment groups) were primarily Gulf fishermen. Non-work-related groups (family and friendship groups) fished in the Gulf and coastal bays almost equally (Table 2). Based on the mean number of trips taken, work-related groups tended to charter more often (Table 3) and were generally larger than non-work-related groups (Table 4). Age comparisons revealed little between group differences (Table 5) and the mean age for each group was nearly equal. However, the 35-54 age category was represented by more of the business client group than any of the others. Also, the youngest age category, 35 years or less, accounted for only 10 percent of the business client groups, considerably less than any of the other three groups in this age category. As with the age comparison, the family, work-related friendship, and non-work-related friendship groups were similar in terms of income (Table 6). However, the business client group again showed considerable difference when compared to the other three group types. Only 2 percent of the respondents entertaining business clients had annual incomes of less than \$20,000. Fifty-four percent of the business client group had incomes greater than \$40,000, and of this 54 percent, 36 percent had incomes greater than \$50,000.

Table 3.—Percentage of charter trips taken by each group type, 1976.

Group type	n	Trips: 1	2-3	4-5	6 or more	Total %	$\bar{x}$[1]
Family	89	25%	45%	17%	13%	100	3.5
Friends	83	25%	39%	17%	19%	100	3.6
Colleagues	51	35%	43%	8%	14%	100	3.8
Clients	50	32%	38%	8%	22%	100	4.4
Total survey sample	273	31%	42%	14%	13%	100	3.8

[1]The mean number of trips reported in this table is slightly higher than the average 3.2 trips reported earlier because respondents may have been members of a different group type on a previous trip.

Table 4.—Distribution of group size for each group type, in percent of total group.

Group type	n	Party size: 2	3	4	5	6	Total %	$\bar{x}$[1]
Family	83	12%	21%	31%	13%	23%	100	4.1
Friends	75	8%	16%	35%	16%	25%	100	4.3
Colleagues	42	9%	10%	24%	14%	43%	100	4.7
Clients	41	5%	5%	29%	22%	39%	100	4.9
Total survey sample	241	9%	15%	28%	17%	31%	100	4.6

[1]Four percent of all groups were larger than 6. These parties utilized more than one charter boat and were thus excluded from the analysis.

Table 5.—Age distribution for each group type.

Group type	n	Age class: <35	35-54	>54	Total %	Mean age
Family	89	21%	51%	28%	100	46
Friends	83	27%	48%	25%	100	45
Colleagues	51	22%	55%	23%	100	45
Clients	50	10%	66%	24%	100	46
Total survey sample	273	23%	51%	26%	100	45

Table 6.—Income distribution for each group type.

Group type	n	Income (×1,000): <\$20	\$20-39	>\$40	Total %	$\bar{x}$
Family	85	24%	47%	29%	100	\$32
Friends	81	30%	36%	34%	100	\$32
Colleagues	51	22%	49%	29%	100	\$31
Clients	50	2%	44%	54%	100	\$41
Total survey sample	267	22%	44%	84%	100	\$33

UNDERSTANDING FISHING MOTIVATION

The qualities sought in a saltwater sport fishing trip can be measured in terms of a number of different motives. These motivations have been defined as fishermen's expectations (Moeller and Engelken, 1972) or as attitudes and behavior of fishermen (Kennedy[3]; Graefe and Ditton, 1976). Some identified motivations of fishermen include the desire to "escape" from the growing demands of civilization, to be outdoors, to be with friends or family, and to enjoy various satisfactions which can be gained specifically through the activity of sportfishing. Spaulding (1970) considers fishing as a form of tension management. Other theorists feel an experience like fishing establishes and sustains the social bond between kin and friends (Cheek and Burch, 1976).

The consideration of motivation allows observations of behavior to be extended by understanding the qualities which an experience provides the recreationists. Satisfaction with fishing experiences has been obtained even if no fish were caught (Addis and

[3]Kennedy, J. 1974. Attitudes and behavior of fishermen in Utah's Uinta Primitive Area. Paper presented at Annual Meeting of the American Fisheries Society, Honolulu, 8-11 Sept. 1974, 16 p.

Erikson, 1969). Similarly, satisfaction has been obtained not from the quantity of fish caught but rather with the quality of the fishing experience (Gordon et al., 1969). Factors unrelated to catch have been found to be more important to the overall enjoyment of fishing than harvest (Knopf et al., 1973).

Multivariate techniques have been useful for understanding human motivation because the causes of human behavior are due to complex multiple variables acting singularly and/or interactively. Multivariate techniques will often reveal the structure underlying these complex relationships and provide insights into new descriptions and explanations of human behavior. Several studies have incorporated multivariate techniques to understand motivations in different recreation situations, some of which include fishing (Spaulding, 1970; Moeller and Engleken, 1972; Knopf et al., 1973; Ballas et al., footnote 1; Roggenbuck[4]; Driver and Knopf, 1976; Graefe[5]).

Table 7.—Description of motive scales derived from 36-item construct scales.

Motive scale name and items	Factor loadings	Alpha reliability	Motive scale name and items	Factor loadings	Alpha reliability
Motive scale 1: Fishing challenge		.84	Motive scale 5: Catch fish		.80
For adventure	.41246		To catch fish	.73950	
To catch a big fish	.79981		For the assurance of a catch	.72293	
For a unique fishing experience	.48579		To catch a lot of fish	.69696	
To catch various types of fish	.51787		Motive scale 6: Personal achievement		.72
For excitement	.43623		To do things on my own	.45283	
For more challenging game fish	.76420		For a convenient means to go fishing	.44837	
To catch a trophy fish	.62465		To learn to be a better fisherman	.51791	
Motive scale 2: Escape		.80	Because people I respect go fishing	.53087	
For relaxation and rest	.55876		To introduce others to fishing	.36188	
To get away from routine demands of family life	.52769		To feel independent	.36218	
To enjoy the tranquility and peace of nature	.50094		Motive scale 7: Affiliation		.55
To relieve my tensions	.84573		To be with people of similar interests	.73258	
To escape the pressures of work	.76585		To be with friends	.60739	
Motive scale 3: Status achievement		.77	To be with other fishermen	.41862	
To do an impressive thing	.37256		Motive scale 8: Adventure experience		.72
To talk about my fishing trip at home	.48336		To have an outdoor experience	.47145	
To be in charge of a situation	.63523		For adventure	.69091	
To show my fishing skill to others	.76259		For excitement	.38497	
To feel independent	.67783		Motive scale 9: Learning about nature		.68
To do things on my own	.36750		To enjoy the tranquility and peace of nature	.51894	
Motive scale 4: Outdoor coastal experience		.78	To learn about nature	.54163	
To be on the ocean	.64649		Unfactored items		
To enjoy the smells and sounds of the coast	.77228		To eat fish		
To be near the coast for its scenic quality	.72040		To establish/maintain business relationships		
To have an outdoor experience	.34662		To have fun		
			Convenience in fishing		

ANALYSIS OF CHARTER FISHING MOTIVATIONS

A procedure was designed to identify charter fishing motives and measure their relative importance. Respondents were provided with an array of 36 hypothesized reasons for charter fishing to be rated on a six point Likert scale ranging from 1="not at all important" to 6="extremely important." Factor analysis was used to identify a smaller set of valid factors or components contained in the array of independent items. Interpretation of the factor analysis resulted in nine motive scales and four unfactored items (Table 7). These will be regarded as 13 motivations of a charter fishing experience. The final determination of the motivations was not based strictly on the mathematical sense provided by factor analysis. Rather, those variables which made statistical sense in a particular scale also had to make sense in terms of the literature and the intuitive meaning of the particular motive being described.

The items which comprise motive scale 1 correlated strongly together. The scale items in motive scale 1 indicate the desire for excitement, adventure, big fish, trophy fish, challenging game fish, unique fishing, and various fish. These items relate to catching a specific type of fish which was anticipated to be part of an adventurous experience. Because of the emphasis in this factor on fishing and having a unique adventure, the motive was named "Fishing challenge." In motive scale 4, "Outdoor coastal experience," all items except "to have an outdoor experience" correlated strongly. Even though the factor loading of "to have an outdoor experience" was low, the item was maintained in this motive scale because it added theoretical meaning. Similarly, the factor analytic process defined the remaining 11 motives. Reliability of each motive scale was determined by the statistical reliability of the final grouping of scale items (Table 7). Each scale item contributed to the overall understanding of the motive being derived.

IMPORTANCE OF MOTIVES

Tabulated motive scale scores across the sample of charter fishermen yield a profile of motives (Table 8). The data show how the defined motives are perceived by respondents. Mean factor importance indicates the average overall importance of each motive with respect to the other motives. Standard deviation provides a measure of how consistently respondents rated motives. It is important to note that the majority of charter fishermen endorse all the dimensions of motivation hypothesized

[4]Roggenbuck, J. W. 1975. Socio-psychological inputs into carrying capacity assessment for float-trip use of whitewater rivers in Dinosaur National Monument. Ph.D. Thesis, Utah State Univ., Logan, 287 p.

[5]Graefe, A. R. 1977. Elements of motivation and satisfaction in the float trip experience in Big Bend National Park. Masters Thesis, Dep. Recreation Parks, Texas A&M Univ., College Stn., 170 p.

MFR PAPER 1320

Preparation of a Menhaden Hydrolysate for Possible Use in a Milk Replacer

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ABSTRACT—Milk replacers are protein sources that substitute for higher valued whole milk for calf feeding. A process, based on the mild hydrolysis of menhaden with pancreatin at pH 7.5, has been developed and yields a product with desirable milk replacer characteristics: high content and quality of protein, low mineral ash and residual fat, and complete solubility. The hydrolysate would be cost competitive with other milk replacer ingredients and represents a higher economic use for menhaden. The process could also be applied to presently underutilized species of finfish of the Gulf of Mexico and south Atlantic areas.

INTRODUCTION

There is a large commercial market for milk replacer formulations in the United States and abroad. Milk replacers are complete rations that are substituted for whole milk in the feeding of calves and other newborn animals (e.g., lambs and pigs). They are of particular value in dairy herds for the feeding of replacement animals, veal calves, and calves which are fed for beef production.

Dried skimmed milk, once the major source of protein in many milk replacer formulations, has been largely replaced by dried whey or casein because of the cost advantage. In recent years, soy proteins have found increased use as an ingredient in combination with milk protein.

The criteria for a top quality milk replacer ingredient (Bauersfeld and Soares, 1972) are: 1) Cost advantage over dry skim milk; 2) consistent quality and chemical composition (80-90 percent protein, less than 1 percent fat, less than 10 percent ash, less than 8 percent moisture); 3) high protein availability and biological value; 4) good suspendability in liquid diet; 5) no strong odor; light in color; 6) low bacterial count; 7) storage stability; and 8) dependable, year-round supply.

There have been several studies on the use of fish protein products as milk replacer ingredients. Huber (1975) reported that fish protein concentrate (FPC) could replace 35 percent of the milk proteins in formulations fed to calves less than 3 weeks old and up to 70 percent of the total protein for older calves, with good results. Huber and Slade (1967) reported successful results when milk replacer diets contained up to 40 percent of the total protein from defatted fish meal, although growth was depressed at levels of 60 percent and above. Bauersfeld and Soares (1972) obtained good results with a replacer diet containing 10 percent condensed fish solubles (50 percent dry matter), but a diet containing 15 percent freeze-dried solubles (equivalent to 30 percent condensed solubles) was found to depress the growth rates of young lambs.

Fish protein is not commercially used in milk replacers in the United States, but significant amounts have been used in milk replacers in Europe. Astra Nutrition[1] of Sweden has sold an FPC product called "Prot-Animal" for use in milk replacers. Although it has protein of high nutritive quality, it has poor suspendability in liquid diets. Two companies of France, however, have developed processes for the production of fish protein hydrolysates with good suspendability for use in milk replacers. Nacoma (of Nantes) has trawlers equipped with shipboard processing equipment for the enzymatic hydrolysis of filleting waste and trash fish. Sopropeche of Boulogne-sur-Mer has been more successful and, according to Tatterson and Wignall (1976), expanded the capacity of their production facilities from 2,000 tons/year to 8,000 tons/year of milk replacer product in 1973. The European market for such fish protein products has been depressed recently by an oversupply of dried skimmed milk, at artificially low prices, due to government subsidies.

The milk replacer market offers an interesting potential for the upgrading of menhaden products to a higher valued product. As fish meal, menhaden sells on a protein equivalent basis for approximately 40¢/pound, while dried skimmed milk is worth about $1.20/pound of protein. The relative costs of several milk replacer ingredients, including cost estimates for the enzymatic hydrolysate of menhaden prepared in this study, are listed in Table 1. Cost estimates were made using a computer program that estimates detailed equipment, "total capital," and operating costs for several different FPC processes (Almenas et al., 1972). It was estimated that the menhaden hydolysate could be produced for 30¢ to 36¢/pound and sold for 50¢ to 65¢/pound to

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[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Table 1.—Milk replacer ingredients—relative costs.

Ingredients	Cost (¢/lb)	Percent protein	Protein cost (¢/lb)
Dried skim milk	41	35	117
Dried whey	8	12	67
Casein	58	90	64
Sodium caseinate	75	93	81
Soy protein	13	50	26
Menhaden hydrolysate			
Low estimate	50	83	60
High estimate	65	83	78

yield an annual after-tax return on total capital investment of 10 percent. Both high and low estimates were based on an assumption of a plant processing 200 tons/day of fish at 3¢/pound, using fuel at 10¢/therm (or 100,000 BTU), electricity at 3¢/kwh, and labor at $5/man-hour. The high estimate was based on 150 days of operation per year and the low estimate on operations for 250 days/year.

PROCESSING STUDIES

In earlier work at the College Park Laboratory of the NMFS Southeast Fisheries Center, several forms of fish protein were evaluated for possible use in milk replacers. Hexane extracted fish meal and FPC were found to have excellent nutritive value but very poor suspendability. Acid and alkaline hydrolysates and a lactobacillus ensilage were relatively poor nutritionally. An enzymatic hydrolysate of menhaden press cake was most promising for use in milk replacers based on a combination of good suspendability and an acceptable nutritive value. Therefore, it was decided to focus on the development of an enzymatic hydrolysate of menhaden or menhaden press cake for possible use in milk replacer formulations.

Initially, both Type A and Type B hydrolysates were investigated. In the Type A process all insoluble solids remaining after hydrolysis are removed by screening and centrifugation. A totally soluble, low-fat powder is recovered by spray drying. Type B is a whole slurry product, liquified by enzymes and screened for removal of bones and scales. It can be produced fairly cheaply, and in high yields, but a high fat content, dark color, and strong odor make it unsuitable for use in milk replacers. To meet the requirements for a first-class milk replacer, it was decided to further evaluate the Type A process.

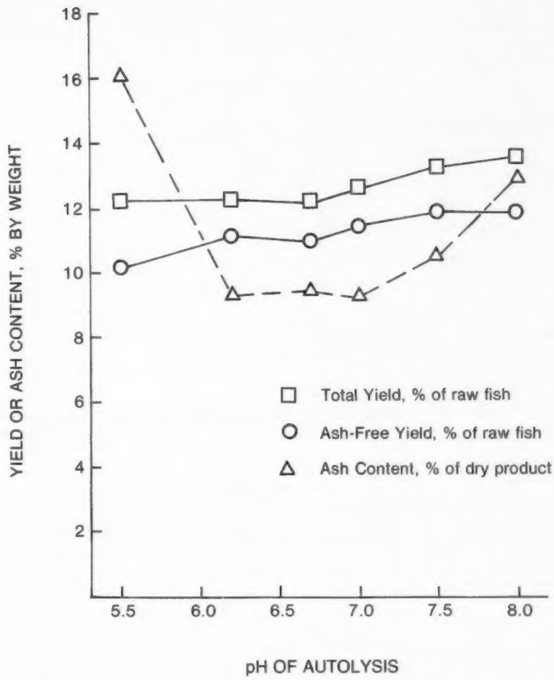

Figure 1.—Yield and ash content versus pH of autolysis of menhaden.

Use of an alkaline bacterial enzyme at pH 8.5 was recommended by Hale (1974) for the preparation of a soluble FPC with good yield, amino acid profile, and nutritive value. However, the soluble ash content of the product was higher than desired for milk replacer use because of the required pH adjustment.

Figure 1 shows the effect of pH of autolysis on the ash content of the dry product as well as total and ash-free yields of the soluble product. Yields are expressed on the basis of the initial weight of raw fish used. Menhaden was autolyzed at six different pH levels ranging from 5.5 to 8.0. Results indicated that at pH 7.5 the ash-free yield was highest and the residual ash content acceptable.

Autolytic activity varies with different catches of fish and a commercial proteolytic enzyme preparation should be added to assure a good reaction rate and yield of soluble product. Pancreatin was more effective than other enzymes tested for hydrolysis of menhaden at pH 7.5. It was also discovered that menhaden hydrolyzed with pancreatin after an initial pH adjustment to 7.5 with calcium hydroxide could be clarified by centrifugation, after hydrolysis, without acidification. This resulted in a soluble product with an ash content after drying of less than 10 percent.

THE PROCESS

The hydrolysis process is outlined in Figure 2. Raw menhaden was ground through a Hobart meat chopper and mixed with an equal weight of preheated water. Calcium hydroxide was added to raise the initial pH from about 6.6 to 7.5. The proteolytic enzyme, pancreatin (4 ×NF), was added at a level of 0.06 percent of the wet weight of fish. The slurry was agitated con-

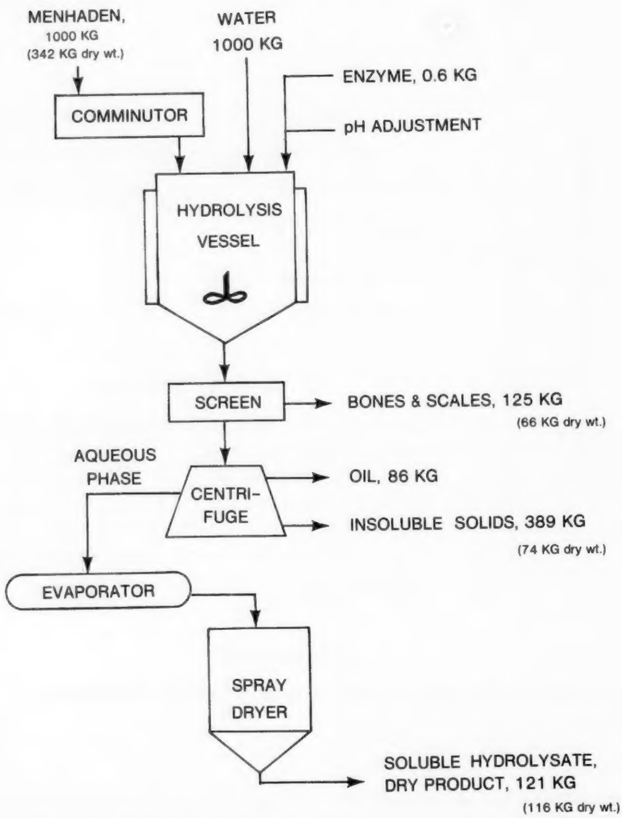

Figure 2.—Hydrolysis process for milk replacer ingredient from menhaden.

tinuously at 52°C (126°F). After 1 hour the pH fell to about 7.0 and was readjusted to 7.5 with NaOH. After a total hydrolysis period of 3 hours at 52°-53°C, the hydrolysate was passed through a 40-mesh screen to remove bones and scales. Insoluble solids and fat were then removed by centrifugation. A final clarification by filtration is optional. The clarified hydrolysate was spray-dried to yield a cream colored and completely soluble product.

Twelve runs were made using the 6-liter glass jars of a New Brunswick fermentor system. A series of additional runs were made with 60-pound batches of menhaden in a jacketed kettle with an air-driven agitator. After removal of insoluble sludge with a Fletcher solid bowl centrifuge, the hydrolysate was heated to 80°C (176°F) and passed through a small DeLaval cream separator to remove free oil. The dry product was then recovered using a Bowen laboratory model spray dryer. The average yield of dry powder was 11 percent of the wet weight of fish.

Although most runs were of necessity made with frozen menhaden, two runs were made with fresh, iced menhaden, and normal results were obtained with no problems in regard to sedimentation or yield. In one pair of runs, chlortetracycline was added to one batch at 250 ppm, but no difference in total bacterial plate counts (TPC) was observed. Hydrolyzed slurries had TPC's of about 500/g and the concentrated, spray-dried products had about 10,000/g.

THE PRODUCT

The spray-dried product satisfies most of the requirements for a first-class milk-replacer ingredient. It is a totally soluble cream powder with about 83 percent protein, less than 10 percent ash, and less than 1 percent total fat. Being moderately hygroscopic the product requires moisture-proof packaging. Proximate analyses are listed in Table 2 for the raw menhaden, enzymatic hydrolysate, and by-product streams of bones and insoluble sludge. The average amino acid analysis for two composite samples, representing a total of eight hydrolysate batches, is shown in Table 3. Calculation of chemical scores (Rama Rao et al., 1959) indicates that the sulfur amino acids (methionine and cystine) are first limiting and isoleucine second limiting nutritionally.

Table 2.—Proximate analyses (percent) for menhaden, hydrolysate, and by-products.

Item	Moisture	Protein	Fat	Ash
Raw menhaden	65.77	14.85	14.91	4.25
(Dry basis)		(43.66)	(43.84)	(12.50)
Bones and scales	47.12	16.93	4.47	27.79
(Dry basis)		(34.42)	(9.09)	(56.50)
Insoluble solids	81.14	9.63	7.65	3.52
(Dry basis)		(46.30)	(36.78)	(16.92)
Soluble product	6.51	82.77	0.80	8.67
(Dry basis)		(89.73)	(0.87)	(9.40)

Table 3.—Amino acid analysis for menhaden hydrolysates.

Amino acid	Average percent of sample weight	Average percent of protein (g/16 g N)
Lysine	7.05	8.45
Histidine	1.79	2.14
Ammonia	1.06	1.28
Arginine	4.95	5.94
Taurine	0.98	1.18
Aspartic acid	10.78	12.92
Threonine	3.51	4.21
Serine	3.34	4.01
Glutamic acid	11.66	13.97
Proline	3.49	4.19
Glycine	5.68	6.81
Alanine	5.51	6.61
Valine	4.20	5.04
Methonine	2.07	2.48
Isoleucine	3.46	4.15
Leucine	6.23	7.47
Tyrosine	2.53	3.03
Phenylalanine	2.93	3.52
Tryptophan	0.95	1.14
Cystine	0.79	0.96
Total	82.96	99.50

The nutritive value of our laboratory-produced pancreatic hydrolysate of menhaden has been determined in several rat feeding trials. Male weanling rats were placed on diets containing 10 percent protein contributed by the test ingredient and diets were formulated to contain sufficient amounts of all other essential nutrients. Rats were fed ad libitum during a 4-week test period. The results of feeding trials with a composite of spray-dried products from four hydrolysate batches (PCR 14-17) are shown in Table 4. The protein efficiency ratio (PER) of the menhaden hydrolysate was at least equal to the casein control diet. All data were analyzed statistically, utilizing a one-way analysis of variance and the Student-Newman-Keuls multiple-range test with $P = 0.05$ set as the level of significance (Steel and Torrie, 1960).

Table 4.—Results of 4-week rat feeding trials evaluating menhaden hydrolysate, PCR 14-17.

Item	*n*	Weight gain ± SE (g)	[1]PER ± SE
		Experiment no. 95	
Casein control	30	124 ± 2.5	3.26 ± 0.032
Menhaden hydrolysate	9	130 ± 4.3	3.24 ± 0.069
		[2]Experiment no. 99	
Casein control	9	107^b ± 2.3	3.02^b ± 0.066
Menhaden hydrolysate	10	120^a ± 3.8	3.30^a ± 0.060

[1]PER = protein efficiency ratio.
[2]Means within a column with different letter superscripts (a, b) are significantly different ($P < 0.05$).

DISCUSSION

The hydrolysis process we have described could best be carried out in conjunction with fish meal processing. It is a relatively mild hydrolysis, and the considerable residue of insoluble solids could be returned to the fish meal process. For an independent processing plant, the insoluble solids and bones would be drum dried and milled to produce an animal feed product.

The pancreatin enzyme was chosen because of its effectiveness at pH 7-7.5 with a resulting low soluble-ash content in the product. An alkaline bacterial protease would be more cost effective at present prices if used at pH 8-8.5, but it would increase the product's ash content. If acidification should be required for proper centrifugation in industrial processing, this would also result in a higher soluble ash content in the final hydrolysate product.

On a protein equivalent basis, the projected cost for the menhaden hydrolysate (Table 1) is only about half as much as dried skimmed milk and is quite competitive with dried whey and imported casein. Soy protein is cheaper, but requires additives for proper suspendibility and the maximum amount that can be used may be limited by nutritional factors, such as amino acid profile or excessive starch content. An effective commercial formulation would probably include both menhaden hydrolysate and soy protein.

The menhaden hydrolysate has a fairly high PER value and supports good growth in small animal feeding trials, but a large-scale calf feeding trial is necessary to establish its value for use in milk replacer formulations. Therefore, the National Marine Fisheries Service is now funding such a study. The menhaden hydrolysate being tested was prepared through the cooperation of the National Fish Meal and Oil Association, with the Zapata-Haynie Corporation, Reedville, Va., supplying plant processing equipment and manpower.

Although fish meal prices have risen to a profitable level, future increases in production costs could possibly make fish meal too expensive for continued use at presently recommended levels. The milk replacer market has a potential for absorbing suitable products derived from menhaden (or other industrial fish) at a higher economic value.

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MFR PAPER 1321

Seasonal Effect on Yield, Proximate Composition, and Quality of Blue Mussel, *Mytilus edulis,* Meats Obtained From Cultivated and Natural Stock

BOHDAN M. SLABYJ, DONN L. CREAMER, and RUTH H. TRUE

ABSTRACT—Seasonal effect on yield, proximate composition, and sensory quality of steamed blue mussel, Mytilus edulis, *meats obtained from cultivated and natural stocks was determined. Both populations (cultivated and natural) gave the highest yield in early spring and a secondary peak was observed in late summer through fall. Minimum yield was detected in June through July after the mussels had completed spawning. The average steamed meat yield of the mussels for the year was 19.4 percent for the cultivated mussels and 13.5 percent for the natural stock. Yield maxima within a single harvest season were related to shell length, which was identical for the two populations examined in spite of age differences. Proximate composition analyses revealed no seasonal change in ash and only a slight variation in lipid content. Moisture, protein, and carbohydrate content were significantly affected by the season. Both cultivated and natural stocks of blue mussels were acceptable throughout the year.*

INTRODUCTION

Blue mussels, *Mytilus edulis,* have been enjoyed by coastal populations in Europe for many centuries. The initial supply of this seafood came from natural mussel beds found in the littoral and sublittoral zone, where mussels are attached to rocks by byssus threads. However, with time and increased demand, fishermen realized the ease with which this mollusk could be cultivated, and developed techniques best suited to their areas. One of the oldest methods of mussel cultivation, which is still practiced in France, is the "bouchot" system where mussels are grown on poles driven into the ocean floor in the intertidal zone.

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A more recent method of propagating and fattening blue mussels is "bottom cultivation" practiced in Denmark, Holland, and West Germany. A third method, very effectively used in southern France, Spain, and Italy, employs ropes which are either fixed horizontally in surface layers of the ocean or suspended from floating rafts (Drinkwaard, 1972; Mason, 1972; Hurlburt and Hurlburt, 1975). Although mussel cultivation is an active industry in England, at least 10 percent of the annual harvest comes from natural mussel beds (Dare and Edwards, 1975).

Off the coast of Maine, natural mussel beds which were harvested, averaging about 9.5 million pounds per year during the period from 1943 through 1946, provided an inexpensive protein source (Scattergood and Taylor, 1949b). A subsequent decline in landings was considered to reflect competition from other protein foods as well as unavailability of good quality mussels (Dow and Wallace, 1954). Nevertheless, a relatively small market was retained supplying the demand of certain ethnic groups in metropolitan areas. As the quality of this seafood is being appreciated by a larger consumer market, increased interest in mussel cultivation has been noticed.

Significant seasonal change in meat yield, observed in cultivated mussels (Mason, 1972) and of mussels obtained from natural beds (Dare, 1976), is known to reflect gonad development and spawning. The proximate composition (protein, carbohydrate, lipid, and ash) has also been observed to show seasonal change (De Zwaan and Zandee, 1972; Dare and Edwards, 1975). The most noticeable change in composition was increased glycogen content in mussels harvested during late summer and fall. This increase was attributed to the type of food which the blue mussels ingested (Drzycimski, 1961). The mineral composition of raw mussel meats was investigated by Segar et al. (1971) and Ball et al. (1975), while the effect of processing on proximate composition and mineral content was reported by Slabyj and Carpenter (1977). Although this shellfish is still primarily marketed in the shell, little information is available on quality loss during transportation and storage (Drinkwaard, 1972; Slabyj and Hinkle, 1976).

The objective of the present study was to determine the seasonal effect on meat yield and proximate composition of freshly steamed blue mussel meats of natural and cultivated stocks, as well as their acceptability throughout the year.

MATERIALS AND METHODS

Blue mussels from natural beds, used in this investigation, were obtained from a commercial source. The mussels were harvested primarily from the intertidal zone near Cushing, Maine. The mussels were washed, graded, and packed in 1-bushel quantities (27.2 kg) in plastic mesh bags and held immersed in the ocean on a raft for 1 or 2 days, for the mussels to cleanse themselves of silt and sand. Sampling was not restricted

to a single mussel bed or a selected age group.

The cultivated mussels were obtained from a limited commercial supply where they were grown on Spanish rafts (Lutz, 1974). Again, sampling was not restricted to a single shell length. All samples were transported and held up to 2 days in ice before being used. In the laboratory all mussels were scrubbed under cold running tap water and briefly drained.

Yield studies were performed by weighing six composite samples, consisting of 30 individuals, before steaming. After steaming the mussels for 6 minutes (Waterman, 1963), the meats and shell were weighed separately and the average shell length of the batch was determined. The meat to shell weight relationship, determined from selected harvests, was obtained by weighing the steamed meats and empty shells of blue mussels of similar shell lengths (±1 mm).

Lipid content was determined on three 50-g composite samples of freshly steamed meats according to the procedure recommended by Bligh and Dyer (1959). Moisture was obtained on 200-g composite samples in triplicate by drying steamed meats to constant weight under vacuum at 70°C. The dried tissue was pulverized in a Wiley (Intermediate) Mill[1] for protein and ash determination (Slabyj and Carpenter, 1977). Carbohydrate content was obtained by difference.

Sensory evaluation was performed on coded steamed meats presented in a randomized complete block design with three replications. When only the natural mussel stock was available for examination (July and August), the steamed meats were presented two at a time, from three replicated steamings. The panelists (13 to 24), many of whom had previously participated in sensory evaluation of mussels, were asked to rate the samples for flavor (5-point scale with 5 representing the best quality) and for texture (7-point scale with 7 representing mushy and 1 representing tough, chewy meats).

[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

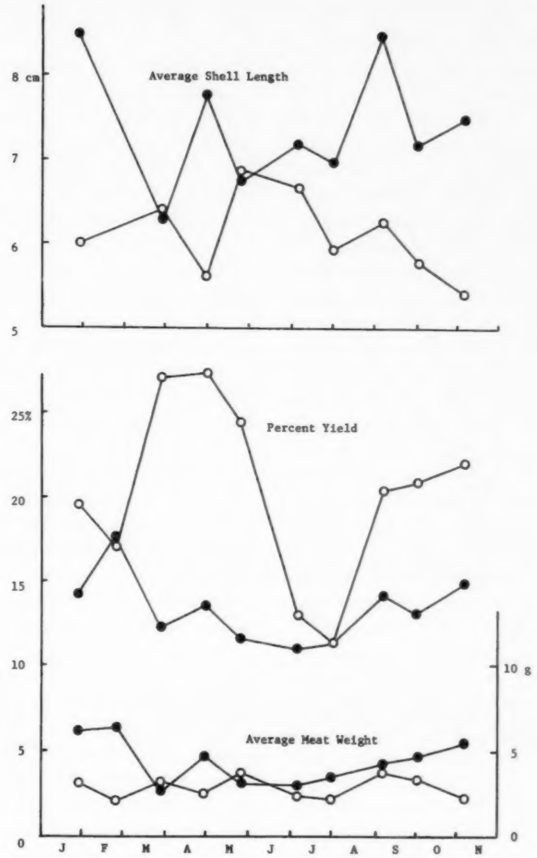

Figure 1.—Seasonal effect on steamed meat yield of cultivated (open circles) and natural stocks (closed circles) of blue mussels in 1976 as related to meat weight and shell length.

The sensory data were analyzed by the variance method, using the treatment × judge interaction (Bliss, 1960) to test for a significant treatment *F* ratio. The least significant difference procedure was used to measure the differences between the two means.

RESULTS AND DISCUSSION

Data obtained on yield determinations for cultivated and natural stocks of blue mussels, *Mytilus edulis*, for 1976 are shown in Figure 1. The cultivated mussels had a maximum steamed meat yield of about 27 percent during the months of March and April. This high yield coincided with the prespawning stage of the mussels, as observed by the grower. The yield dropped to a minimum of 11.5 percent in August, but rose to a secondary peak (22.1 percent) in the fall.

Mussels obtained from natural beds revealed a relatively small peak in yield during the month of February (17.8 percent). This yield dropped to a minimum of about 11 percent in July and August, and subsequently had a secondary peak (14.8 percent) in the fall. Since these mussels were obtained from different mussel beds located primarily in the littoral zone, it is not

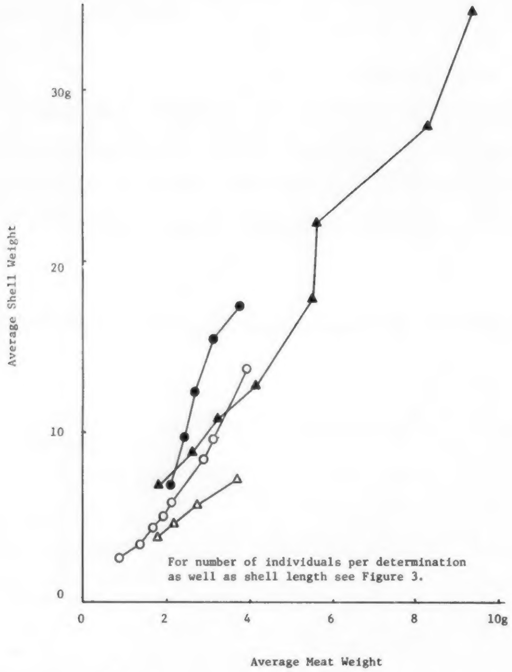

Figure 2.—Relationship between steamed meat and shell weight of cultivated (open circles and triangles) and natural stocks (closed circles and triangles) of blue mussels harvested in July 1976 (circles) and March 1977 (triangles).

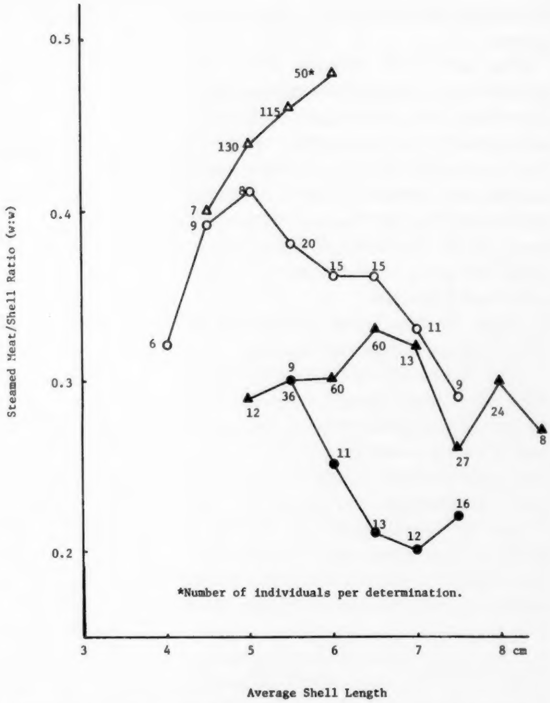

Figure 3.—Shell length VS steamed meat/shell ratio of cultivated (open circles and triangles) and natural stocks (closed circles and triangles) of blue mussels harvested in July 1976 (circles) and March 1977 (triangles).

surprising to observe a relatively small peak in yield during the spring season. Meat yields from different mussel beds are known to vary noticeably (Scattergood and Taylor, 1949a). In fact, from the data presented in Figures 2 and 3, it can be estimated that blue mussels of the natural stock harvested in March of 1977 exhibited an overall yield of about 20 percent. Factors such as food availability, light intensity, wave action, exposure to air, and population density will adversely influence meat yield (Baird and Drinnan, 1957; Mason, 1972; Dare and Edwards, 1975). Furthermore, the fisherman, from whom the mussels were obtained, avoided harvesting mussels that could spawn in transit. According to his experience, such mussels are sensitive to handling and may die.

Variability in yield at each sampling was relatively low for each population (standard deviation of 0.3 to 2.0 percent), with an average standard deviation for the year of 0.8 and 0.9 percent for natural and cultivated stocks, respectively.

The average meat weight of individual mussel meats of the natural stock at each sampling appeared to be heavier than the meats from the cultivated stock (47.6 percent) (Fig. 1). Such a difference was anticipated in view of the fact that the shells of the natural stock were, on the average, 19.6 percent longer (Fig. 1). The overall yield of the cultivated stock examined was observed to be 19.4 percent, while that of the natural stock was 13.5 percent. This difference represents a 43.7 percent higher yield by the cultivated stock. The primary reason for this difference is that the cultivated mussels in this investigation had a shell which was about 30.4 percent lighter than that of the natural stock. It is also known that mussels grown on Spanish rafts have slimmer shells than those from the intertidal zone. The mussels from the latter source would tend to trap more water when harvested, reducing the overall meat yield.

Scattergood and Taylor (1949a) reported similar fluctuation in raw meat yield of mussels harvested at Boothbay Harbor, Maine. They observed a maximum yield of 32.2 pe.cent in June and a minimum of 19.0 percent in July. It may be of interest to compare this raw meat maximum of 32.2 percent yield for mussels obtained 2 feet above the low-water mark in Maine waters, with the 27.3 percent maximum yield of steamed meats for cultivated mussels in the present investigation, knowing that

syneresis accounts for 6.6 percent of shrinkage (Slabyj and Carpenter, 1977). Meat yields observed in a commercial plant for January (10.0 percent) and April (14.6 percent), as reported by Scattergood and Taylor (1949a), resemble data reported in the present study for mussels harvested from natural beds.

Other investigators have also observed seasonal changes in the meat content of blue mussels, attributing the loss in meat weight to spawning (Dare and Edwards, 1975; Dare, 1976). The timing of this change in yield was somewhat different and the peaks were reversed when compared with the present investigation.

In order to determine the meat to shell weight relationship at a single harvest, these parameters were plotted for mussels of similar size (Fig. 2). This graph indicates a linear relationship between the meat and shell weight. It is important to note that this relationship is not fixed, but changes with the season in both populations (cultivated and natural stocks). Such a change was anticipated, since mussels harvested in the spring have well-developed gonads, at which time the meats almost entirely fill the shell cavity, while mussels harvested in the summer have gonads which are reduced to a minimum. Baird and Drinnan (1957) observed a similar relationship when plotting raw meat weight against shell weight of mussels of similar size. Regression lines fitted to their data appear to have slopes of 3.0 and 4.2 for mussels obtained from sublittoral and littoral zones, respectively.

Since the slope of the regression line is indicative of yield (the shallower the slope the higher the yield), it is possible to compare yields of different populations. Although Baird and Drinnan (1957) did not indicate the season when their study was conducted, the slope of their regression line for the littoral mussels falls within the values obtained for mussels harvested from natural beds in March and July as presented here (3.7 and 6.3, respectively). Similarly, the slope of the regression line for the sublittoral mussels (3.0) is comparable with that of cultivated mussels in the present study harvested in March and July (1.6 and 3.7, respectively) (Fig. 2).

When using meat and shell weight data and plotting shell length against a ratio of meat/shell weight (Fig. 3), it is possible to detect not only a difference in "apparent" yield between the two populations (cultivated and natural stocks) and between the two seasons of harvest (July and March), but also a difference in maximum yield associated with shell size within a single harvest. The apparent yield cannot readily be converted to actual yield, as given in Figure 1, since it is not known what weight "mussel liquor" (seawater trapped by closed shells) constituted. For this reason, the use of steamed meats to shell weight ratio, instead of the actual yield, has been preferred in order to avoid problems associated with liquor loss in harvested mussels (Drinkwaard, 1972; Coleman, 1973; Slabyj and Hinkle, 1976).

From the limited number of samples examined, it appears that the 6.5-cm mussels gave maximum yield in early spring, while in the fall the maximum yield was obtained from the 5.0-cm long mussels, regardless of whether they were of the cultivated or of natural stock. This perhaps indicates that the 6.5-cm mussels have the greatest capacity to recruit all resources for reproduction, while the 5.0-cm mussels have the highest tissue to shell ratio in a non-spawning population. The similarity in the yield pattern, as related to shell length of the two populations, is noteworthy in that these mussels came from different areas of the Maine coast, were of different age groups, and grew in a different environment.

Meat yield of blue mussels harvested from natural beds with a shell length greater than 7.0 cm did not follow a general pattern (Fig. 3). One can notice a dip in yield for the March population and a slight increase for the population harvested in July. An explanation for this phenomenon cannot be derived from the present study.

It may be of interest to point out that from 27,240 kg (1,000 bushels) of blue mussels harvested in March (Figs. 2 and 3), the anticipated steamed meat yield for the 6.5- and 7.5-cm mussels would be 6,292 kg (23.1 percent) and 5,285 kg (19.4 percent), respectively, assuming that liquid which these mussels can trap may represent 70 percent of the raw meat content (Slabyj and Hinkle, 1976) and syneresis may account for 6.6 percent shrinkage (Slabyj and Carpenter, 1977). Although the yield difference is only 3.7 percent, it is obvious that the difference in amount of meat obtained is 19.1 percent. Similarly, the 5.5- and 7.0-cm mussels harvested from natural beds in July would result in 5,067 kg (18.6 percent) and 4,004 kg (14.7 percent), respectively, per 27,240 kg of blue mussel shell stock, when correcting for syneresis and assuming that liquor associated with these mussels was about 1.2-fold higher than their meats. Again, the yield difference is only 3.9 percent, but the difference in amount of meat obtained from these two different size mussels is 26.5 percent.

Proximate composition of steamed blue mussel meats for the natural stock is shown in Figure 4. The minimum moisture content was 70. 8 percent and the maximum 75.8 percent. It appears that increased moisture retention of steamed meats is related to the post-spawning stage of the mussels.

Maximum protein content was observed to be 20.2 percent and the minimum 14.7 percent. During most of the year the carbohydrate content was low (about 2.2 percent), except in late summer and fall when the peak reached 6.1 percent. It appears that the drop in carbohydrate content reflects increases in moisture and protein concentrations. Lipid content was relatively low, about 3 percent, and revealed only a minor drop in concentration during the months of May through August. Little change was observed in ash content throughout the year with an average of 2.3 percent. Proximate composition of the steamed meats of cultivated stock (Table 1) is essentially the same as that obtained for mussels harvested from natural mussel beds.

Protein and carbohydrate content of both the natural and the cultivated stock is comparable with that reported by other investigators (Drzycimski, 1961; De Zwaan and Zandee, 1972; Dare and

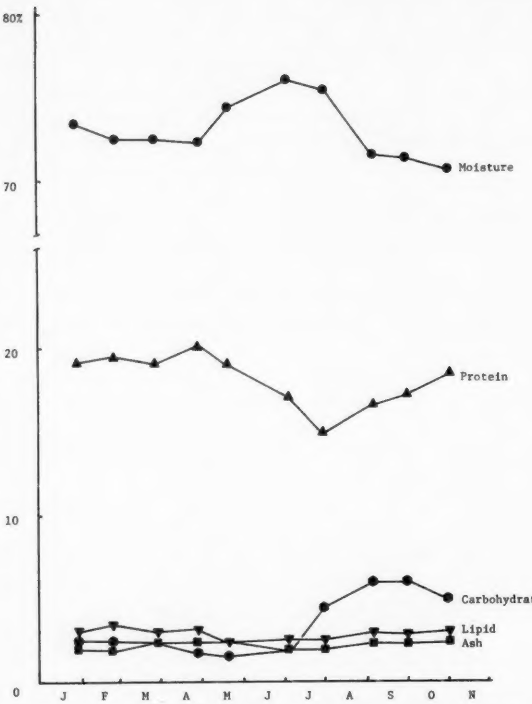

Figure 4.—Seasonal effect on proximate composition of steamed blue mussel meats of natural stock harvested in 1976.

Table 1.—Seasonal effect on proximate composition of steamed blue mussel meats of cultivated stock in 1976.

Date	Moisture	Protein	Crude fat	Ash	Carbohydrate
1/30	[1]73.5(0.3)	19.5(0.2)	2.8(0.1)	2.0(0.1)	2.2
2/26	73.3(0.5)	20.6(0.4)	2.8(0.1)	2.1(0.1)	1.3
3/29	73.7(0.7)	19.1(0.1)	3.4(0.2)	2.2(0.1)	1.7
4/29	73.0(0.4)	20.1(0.1)	3.1(0.2)	2.7(0.1)	1.2
5/27	71.5(0.2)	21.0(0.2)	3.3(0.2)	2.2(0.1)	2.0
7/6	75.7(0.1)	16.5(0.2)	2.6(0.2)	2.4(0.1)	2.8
8/1	75.0(0.6)	14.1(0.2)	2.7(0.2)	2.3(0.1)	5.8
9/7	72.2(0.5)	16.8(0.4)	3.2(0.2)	2.0(0.1)	5.8
10/2	71.1(0.2)	18.6(0.1)	3.3(0.1)	2.6(0.1)	4.4
11/1	71.3(0.4)	18.7(0.3)	3.5(0.1)	2.5(0.1)	4.1

[1]Values in parentheses represent standard deviation on three determinations.

Table 2.—Seasonal effect on flavor and texture of cultivated and natural stock of steamed blue mussel meats harvested in 1976.

Month harvested	No. of judges	Flavor means[1] Cultivated	Flavor means[1] Natural	Texture means[1] Cultivated	Texture means[1] Natural
Feb.	23	4.06	3.87	4.35 a	3.86 b
Apr.	23	4.17 a	3.41 b	4.67	4.30
May	21	3.98	3.89	5.13 a	4.21 b
June	16	4.00 a	3.62 b	4.60 a	4.06 b
July	13	—	3.96	—	4.08
Aug.	13	—	3.99	—	4.27
Sept.	24	3.76	4.01	4.50	4.38
Oct.	19	3.54	3.79	4.53	4.21
Nov.	22	3.68	3.73	4.59 a	4.05 b

[1]Means followed by different letters differ at $P \leq 0.05$ for that sampling period.

Edwards, 1975) for raw meats, taking into account the effect of steaming (Slabyj and Carpenter, 1977). The timing of the changes is, however, different. Drzycimski (1961) observed a more pronounced drop in lipid content as the result of spawning than was observed in the present study. Both Drzycimski (1961) and Dare and Edwards (1975) reported a significant increase in ash content which was attributed to change in protein concentration. A similar change in ash content was not observed in the present investigation.

Taste panel studies (Table 2) indicated that the cultivated mussels had slightly better flavor than the mussels obtained from natural stock. This is not surprising, since mussels growing in natural beds are in intimate contact with the ocean floor and may pick up the odor of their surroundings. This difference in flavor was only significant ($P \leq 0.05$) in April and June. No apparent change in quality was detected throughout the year in either population.

Texture means (Table 2) revealed that freshly steamed meats obtained from the cultivated stock were slightly softer than those of the natural stock, except when harvested in September and October. This observation was statistically significant ($P \leq 0.05$) in February, May, June, and November. It should be pointed out, however, that the softer texture of the cultivated mussels does not imply that this characteristic was in any way considered to be less desirable. Mussels harvested during the month of April were not considered especially soft or mushy when compared with those obtained during the remainder of the year, although the yield data indicated that these mussels were in the prespawning stage with very well-developed gonads.

Although occurence and size of pearls were not evaluated, no pearls were detected in the cultivated stock, while they were present to varying degrees in the meats of natural stocks.

In summary, it should be pointed out that the yield from both, cultivated mussels as well as mussels obtained from natural beds, was highest in the spring and slightly lower in late summer through fall. Minimum yield was obtained in June and July after the mussels had completed spawning. The overall meat yield of the cultivated mussels was considerably higher than that obtained from natural beds. Yield maxima were related to shell length within a population and both populations (cultivated and natural) exhibited the same change in yield pattern with the season. No seasonal variability in ash and only a slight change in lipid was observed. Moisture, protein, and carbohydrate content showed significant

seasonal effect. It was also observed that texture and flavor of mussel meats of both populations were acceptable throughout the year, although the quality of the cultivated stock was more consistent.

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MFR PAPER 1322

Catch-Effort and Price-Cost Trends in the Gulf of Mexico Shrimp Fishery: Implications on Mexico's Extended Jurisdiction

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INTRODUCTION

The Gulf of Mexico shrimp fishery is the most valuable fishery in the United States today. In 1976 U.S. fishermen landed over 5.4 billion pounds of fish for a total value of $1,352.7 million. United States shrimp landings were 403.6 million pounds, only 7.5 percent of pounds landed, but accounted for 24.5 percent of the total dollar value. Shrimp landed in Gulf of Mexico ports made up 83.0 percent of the total value of shrimp landed in the United States and 20.3 percent of the total value of all fisheries in the United States (Robinson, 1977).

The future well-being of the Gulf of Mexico shrimp fishery is dependent on economic as well as biological factors. The size of the biomass, environmental conditions, reproductive ability, and other physical factors are only one part of this complex system. Of equal importance are the year-to-year changes in fishing effort, and costs and returns which make up the economic part of the fishery. A complete analysis of the fishery's status should include all of the above factors.

The purpose of this paper is to review trends in the catch-effort and price-cost relationships in the Gulf of Mexico shrimp fishery. In addition, these relationships provide a rudimentary framework for analyzing the effect of Mexico's extended 200-mile jurisdiction. This paper updates the data series presented by Nichols and Griffin (1975) and also provides a more accurate estimate of fishing effort by shrimp vessels (Griffin, 1977).

The information presented is based on data from two sources. The catch-effort data was collected by the National Marine Fisheries Service (NMFS) from all vessels (5 gross tons and larger) landing shrimp at U.S. Gulf ports. This data is summarized in Tables 1 and 2. The price-cost data was collected through personal interviews with vessel owners operating in Florida and Texas by Texas A&M University. This data is summarized in Table 3.

TRENDS

Effort

There are several measures of fishing effort available which help explain past changes in landings and may help in predicting future landings. Number of vessels in the fishery is one such measure of the trend in fishing effort. The number of vessels of 5 gross tons and larger landing shrimp at U.S. Gulf ports is presented in Figure 1. In 1962 the number of vessels was 2,542; in 1974 their number had increased 28 percent to 3,247. In 1974 vessels accounted for 70 percent of shrimp landed from U.S. waters. The remainder was landed primarily from inshore by smaller boats not included in this study. Shrimp in Mexican waters is caught exclusively by vessels where most of these vessels have home ports in Texas or Florida.

A second measure of fishing effort is the total number of nominal days fished. This series for U.S. and Mexican waters is indicated in Figure 2. Each nominal day measured represents a full 24 hours fishing on the shrimp grounds. Nominal days fished in U.S. waters by vessels has increased substantially since 1962 while decreasing by over 50 percent in Mexican waters. The total of the two areas shows an increase in nominal days fished by vessels. Subsequent to the recently negotiated agreement with Mexico, fishing in Mexican waters is to be phased out entirely by 1980.

Most observers agree that the total

Table 1.—Gulf of Mexico commercial shrimp landing data from U.S. waters by vessels and total Gulf 1962-75.[1]

	Total Gulf of Mexico			U.S. waters							
Year	Landings[2] (10^6 lb)	Value[3] ($\$10^6$)	No. Vessels	Landings (10^6 lb)	Value ($\$10^6$)	Nominal days fished (10^3)	Index of days fished (1962 = 100)	Total effort[4] (10^3)	Index of effort (1962 = 100)	CPUE (lb)	$/lb
1962	89.0	60.3	2,542	45.4	33.4	88.5	100	144.0	100	315	0.74
1963	124.7	61.3	2,653	77.0	41.5	112.9	128	181.8	126	423	0.54
1964	113.3	62.6	2,795	71.0	40.7	114.4	129	186.3	129	381	0.57
1965	123.4	71.2	2,804	80.1	49.1	113.7	129	187.6	130	427	0.61
1966	113.6	83.6	2,924	78.3	61.9	113.7	129	190.5	132	411	0.79
1967	140.6	90.1	3,098	99.7	68.5	116.0	131	201.7	140	494	0.69
1968	128.2	95.7	3,346	83.7	68.4	121.5	137	218.1	151	383	0.82
1969	126.6	101.2	3,362	82.4	74.3	147.8	167	273.6	190	301	0.90
1970	145.3	108.1	3,298	96.1	81.4	134.6	152	249.1	173	386	0.85
1971	143.1	136.1	3,282	91.3	100.8	137.0	155	259.0	180	352	1.10
1972	143.8	163.7	3,496	94.3	120.1	146.8	166	282.6	196	333	1.27
1973	114.8	171.0	3,453	71.0	118.6	140.0	158	269.7	187	263	1.67
1974	117.1	137.5	3,247	73.9	99.8	132.4	150	243.6	169	303	1.35
1975	107.0	178.2									

[1]Derived from NMFS data tapes on Gulf of Mexico shrimp landings.
[2]Includes catch by vessels and boats.
[3]Includes value by vessels and boats.
[4]Effort is real days fished.

Table 2.—Gulf of Mexico commercial shrimp landings. Value and days fished from Mexican waters, 1962-75.[1]

Year	Pounds (10^6)	Value (\$$10^6$)	Days fished (10^3)	Nominal days fished (1962 = 100)	Total effort[2] (10^3)	Index of effort (1962 = 100)	CPUE (lb)	\$/lb
1962	19.1	15.7	38.0	100	61.7	100	309	0.82
1963	14.0	10.2	26.3	69	43.6	71	322	0.73
1964	17.4	11.4	31.9	81	51.6	84	337	0.64
1965	16.3	11.7	28.0	73	46.6	76	350	0.71
1966	10.1	9.1	17.5	46	29.8	48	430	0.90
1967	10.8	9.1	14.6	38	33.2	54	300	0.91
1968	14.4	13.9	23.0	60	42.4	69	338	0.97
1969	8.3	8.9	16.9	44	31.8	51	262	1.07
1970	9.1	9.1	15.5	41	28.3	46	320	1.00
1971	9.1	11.5	14.8	39	28.9	47	313	1.26
1972	11.7	16.0	16.8	44	32.8	53	357	1.37
1973	10.1	18.8	17.7	47	34.7	55	291	1.85
1974	10.2	15.0	18.7	49	35.3	57	289	1.47
1975	7.5	16.3	11.5	30				2.15

[1]Derived from NMFS data tapes on Gulf of Mexico shrimp landings.
[2]Effort is real days fished.

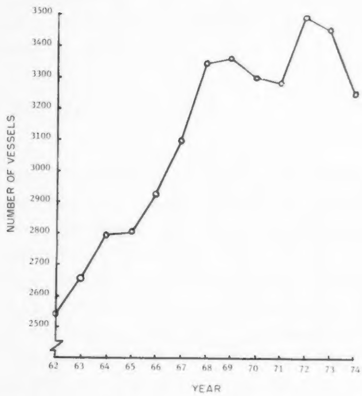

Figure 1.—Number of vessels 5 gross tons and larger that landed shrimp in the Gulf of Mexico shrimp fishery, 1962-74.

Table 3.—Annual costs and returns for Gulf of Mexico vessels of steel and wood construction, 51 to 80 feet in length, and 104 to 425 horsepower.[1]

	1971	1973	1974	1975
Returns				
Gross receipts from shrimp sales	\$60,742	\$74,135	\$78,864	\$101,324
Lb. landed	50,656	39,907	46,270	44,070
Price/lb.	\$ 1.20	\$ 1.86	\$ 1.70	\$ 2.30
Costs				
Variable:				
Ice	\$ 1,387	\$ 1,579	\$ 1,541	\$ 1,766
Fuel	6,561	9,539	18,976	19,114
Nets, supplies, groc.	2,358	6,747	9,885	11,211
Repair & maintenance	11,708	9,593	9,337	11,643
Subtotal variable costs not proportional to catch	22,014	27,458	39,739	43,734
Crew shares	19,437	23,723	26,593	32,422
Payroll raxes	388	474	1,547	1,815
Packing	2,411	1,899	2,428	2,905
Total variable costs	44,250	53,554	70,307	80,876
Returns above variable costs	16,492	20,581	8,557	20,448
Fixed costs				
Insurance	3,632	4,291	4,306	4,840
Depreciation	6,333	8,177	11,228	12,607
Overhead	0	2,415	3,201	3,073
Interest	2,256	2,611	5,604	6,984
Total fixed costs	12,221	17,494	24,339	27,504
Total costs of operation	56,471	71,048	94,646	108,380
Total profit/loss from operations	4,271	3,087	−15,782	−7,056
No. of vessels in class	25	103	109	101

[1]Derived from unpublished cost and returns data collected by Department of Agricultural Economics, Texas A&M University.

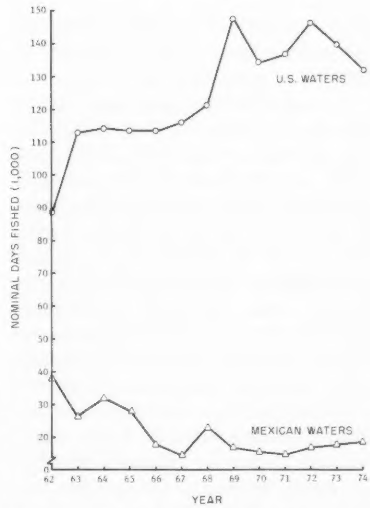

Figure 2.—Nominal days fished (24-hour equivalent) by U.S. shrimp vessels in United States and Mexican waters of the Gulf of Mexico, 1962-74.

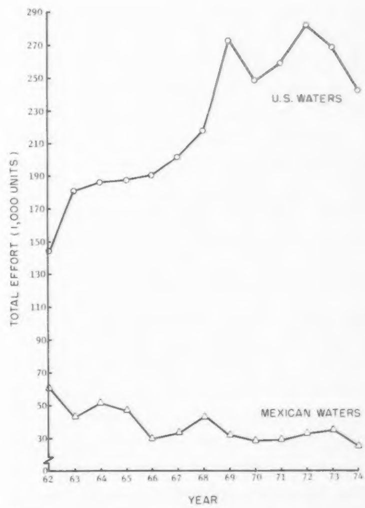

Figure 3.—Total effort units (real days fished) expended by U.S. shrimp vessels in United States and Mexican waters of the Gulf of Mexico, 1962-74.

number of nominal days fished is a rather crude measure of effort in that it fails to account for changes in the nature of the vessels in the fleet over time. Intensity of shrimp fishing effort is increasing as vessels upgrade their potential productivity with larger horsepower engines and net size. A precise mathematical formulation for expressing relative fishing power of vessels based on horsepower and net size is presented in Griffin et al. (1977). Adjusting nominal days fished by relative fishing power of vessels, Figure 3 shows that in U.S. waters effort (now defined as total real days fished) increased perceptibly from 1966, reached a peak in 1972, and has declined somewhat in later years. The impact of adjusting for this change in relative fishing power over time is illustrated by the index of nominal days fished and index of effort series where the base year for both series is 1962 equal to 100 (Fig. 4). Fishing effort in U.S. waters is increasing faster than nominal days fished. While nominal days fished increased by 55 to 65 percent from 1962 to a peak in 1972, total effort increased by 80 to 90 percent during the same time. The difference is due to the gradual increase in vessel horsepower

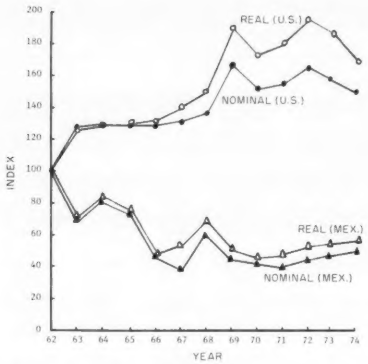

Figure 4.—Index of nominal and real days fished by U.S. shrimp vessels in U.S. waters of the Gulf of Mexico, 1962-74.

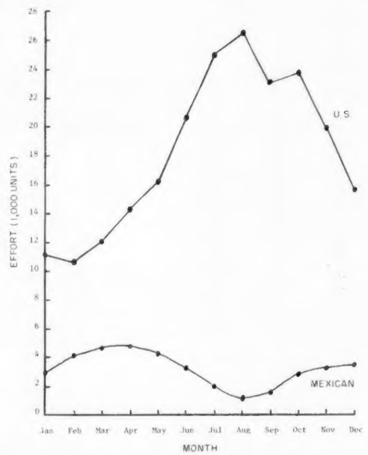

Figure 5.—Seasonality of total effort units (real days fished) by U.S. shrimp vessels in United States and Mexican waters of the Gulf of Mexico, 1963-71.

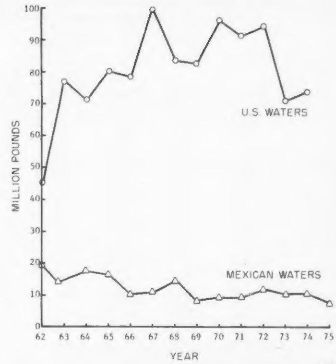

Figure 6.—Landings of shrimp by U.S. vess from United States and Mexican waters of the Gulf of Mexico, 1962-74 (heads-off weight).

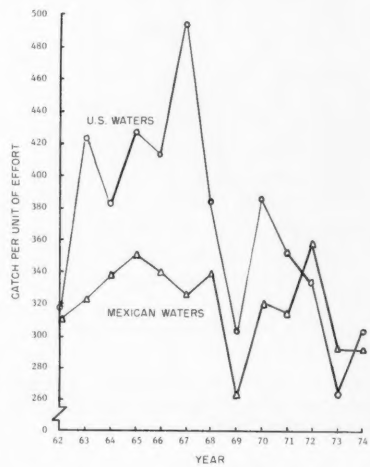

Figure 7.—Catch per unit effort for U.S. vessels 5 gross tons and larger, United States and Mexican waters of the Gulf of Mexico, 1962-74 (heads-off weight).

and net sizes used in the industry (Griffin et al., 1977).

Effort in Mexican waters (Fig. 3) has trended downward as observed above in the nominal days fished series (Fig. 2). The decline in total effort appears slower than the decline in days fished (Fig. 4), again reflecting an increase in fishing power of the average vessel.

Another area of interest with respect to total fishing effort in U.S. and in Mexican waters is the seasonality of effort. This is depicted in Figure 5. Total effort in U.S. waters is of magnitudes 3 to over 20 times that of total effort in Mexican waters over a year; however, the oscillations in each are completely opposite—the highest effort in U.S. waters corresponds with the lowest in Mexican waters. During the first 4 months of the year, from 20 to 28 percent of total effort in the Gulf takes place in Mexican waters. This has caused serious adjustment problems for those vessels no longer able to fish in Mexican waters.

Catch

Little change is noted in the composition of shrimp landings in the past decade. Brown, *Penaeus aztecus*, white, *Penaeus setiferus*, and pink, *Penaeus duorarum*, shrimp compose nearly all of these landings. The most noticeable shift among these has been a relative decline in landings of pink shrimp from 22 percent in 1965 to 15 percent in 1975. Brown shrimp landings have increased in share from 51 percent in 1965 to 57 percent in 1975.

Shrimp landings from the Gulf are presented in Table 1. With the exception of years 1962, 1973, 1974, and 1975, shrimp landings by vessels in U.S. ports show only an approximate 25 percent increase in landings from U.S. waters, despite the large increase in total effort. Year-to-year variations in total catch are significant and are influenced by poor environmental conditions in some years which prevent either adequate growth in the shrimp biomass or the shrimp fleet from fishing (Fig. 6). The catches in 1962, 1973, and 1974 serve as examples of large variations in yearly catch when the Mississippi River discharge was high (Barrett and Gillespie, 1973; Griffin et al., 1976).

The decline in shrimp landings from Mexican waters, however, is entirely consistent with the decrease in total fishing effort in Mexican waters over time (Table 2). Evaluating U.S. shrimp landings from the Gulf of Mexico as a whole shows no clear increasing or decreasing trend over the 1962-74 period, as others have pointed out before (Nichols and Griffin, 1975). In fact, landings have been stabilized at roughly 195 million pounds, heads-on weight, since 1950.

Catch/Unit

Catch per unit effort (CPUE) is calculated by simply dividing the appropriate catch statistic by its accompanying total effort statistic, as developed earlier. The result is illustrated in Figure 7, which shows catch per unit effort for vessels landing shrimp from U.S. and from Mexican waters. Of interest is

that while U.S. CPUE has declined over time from approximately 400 pounds to approximately 300 pounds, CPUE in Mexican waters has stayed relatively constant at approximately 300 pounds.

In addition to calculating CPUE, a relationship was established between shrimp landings and total effort from U.S. waters by vessels. In this way, holding all other factors constant, landings can be predicted at various levels of total fishing effort. One other factor considered in this relationship was river discharge during the months that shrimp are in their nursery grounds. A high discharge reduces temperature and salinity, causing population and, in turn, landings to be reduced (Griffin et al., 1976). The yield relationship used was of the form

$$Y=b_0\, D^{b2\,(1.0-(b_1)^E)} \qquad (1)$$

where b_0D^{b2} is the maximum yield the function approaches for a given level of river discharge, D[1]. Here, the Mississippi River discharge, reported by the U.S. Army Corps of Engineers (1961-74), is used for D. E is the total effort in U.S. waters. The term b_1 indicates the ratio by which incremental products of E decline. The above equation was estimated using regression analysis and time-series data for the period 1962-74 as follows:

$$Y=6{,}593\, D^{-0.60134\,(1.0-0.995701^E)} \qquad (2)$$

where Y is in million pounds and E is in thousand units.[2]

Using an average daily river discharge of 696 cubic feet per second, the maximum yield for vessels in the shrimp fishery is estimated to be 128.7 million pounds annually. This relationship is such that the maximum yield is approached asymptotically by increased effort. An increase in effort in U.S. waters by 50 percent from 180,000 units to 270,000 units would cause an increase in expected catch from 69.4 million to 88.5 million pounds, respectively, which is an increase of 27.5 percent. The estimated equation indicates that CPUE was 15 percent less in the early 1970's than in the early 1960's.

Prices-Costs

Attention is now turned to the individual vessel's costs and returns for operating in the Gulf of Mexico. While the number of vessels interviewed make up a very small sample of all vessels, the data presented in Table 3 generally reflect changes felt by all vessels. Average gross receipts ranged from a low of $60,742 in 1971 to a high of $101,324 in 1975. Average landings per vessel was highest in 1971 at 50,656 pounds; lower landings in 1973-75 reflect a high level of river discharge experienced in those years. The price per pound received by these vessels almost doubled from $1.20 in 1971 to $2.30 by 1975.

Costs are broken into three categories: Fixed costs, variable costs proportional to catch, and variable costs not proportional to catch. Variable cost items not proportional to catch include ice; fuel; nets, supplies, and groceries; and repair and maintenance. These costs almost doubled during 1971-75, with fuel tripling in cost and nets, supplies, and groceries increasing by five times. Costs proportional to catch include crew shares, payroll taxes, and packing charges.

Total variable costs for these vessels almost doubled from $44,250 in 1971 to $80,876 in 1975. Returns above variable costs remained relatively constant from 1971 to 1975 at approximately $20,200, except for 1974 when it dropped to only $8,557. Thus, in 1974, after paying for variable costs, very little was left over to pay for fixed costs.

Fixed cost includes insurance, depreciation, overhead, and interest. Of these four items the significant increases are in depreciation and interest since these two items reflect the cost of a new vessel[3]. Thus, based on new vessel prices, depreciation and interest more than doubled. This caused fixed costs to more than double from $12,221 in 1971 to $27,504 in 1975.

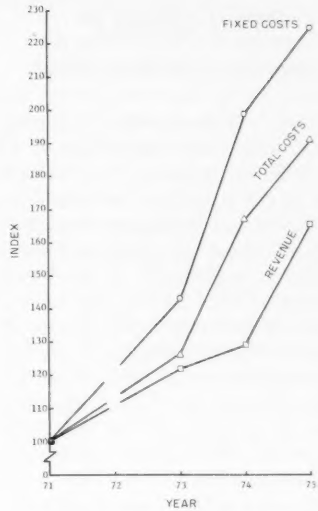

Figure 8.—Indices of costs and revenues for U.S. shrimp vessels operating in the Gulf of Mexico, 1971 and 1973-75 (1971 = 100).

Total costs (variable plus fixed) almost doubled during this 5-year period, from $56,471 to $108,380. Since revenues increased at a slower rate than costs, this caused negative returns in 1974 and 1975 of $15,782 and $7,056, respectively.

Rates of increase in the cost components and in total revenue are illustrated in Figure 8. Costs and revenues are in the form of indices (1971 = 100) which are calculated so that they reflect the nominal percentage increase in each item. All items showed the first significant increase in 1973. Fixed cost shows the most increase of 125 percent while revenue shows the least increase of 66 percent.

[1]Because of the regression technique used, the actual equation estimated was $Y=b_0D^{b2(1.0-b_1{}^E)a}$. Theoretically, $a=1$; therefore, b_1 was solved for through an iterative procedure such that a approaches 1.

[2]Coefficients were significant at the 99 percent level. R^2 was 78.5; Durbin-Watson was 2.25. The simple correlation coefficient between landings and effort is 0.64 and between landings and discharge is −0.63.

[3]Detailed discussion of the methodology to calculate depreciation and interest will not be presented here as they are available elsewhere; see Robinson (1977).

IMPLICATIONS OF MEXICO'S EXTENDED 200-MILE JURISDICTION

Mexico's 200-mile offshore fishing zone officially went into effect on 27 July 1976. At present, U.S. vessels must secure temporary permits until 1980 to continue shrimping in Mexican waters. Without any future reciprocal or bilateral agreements, vessels which do some or all of their fishing off the coast of Mexico will be forced to do all of their shrimping off the Gulf coast of the United States after 1980. The effect of this will be to shift vessels and total effort geographically by the Gulf shrimp fleet. This in turn implies serious consequences for the individual vessel owner and the industry as well.

The landings-effort relationship derived in Equation (2) was used to help trace through the effect of shifting effort from Mexican to U.S. waters. Using average effort expended for 1970-74 as a base, if all effort in Mexican waters were shifted to U.S. waters, effort increases 12 percent (260,800 to 291,400 units) and expected catch increases by 6 percent (87 million to 97 million pounds); CPUE would decrease from 325 pounds per unit to 310 pounds per unit (Griffin and Beattie, 1977).

Assuming that part of the industry operating in U.S. waters was in a state of equilibrium, i.e., total receipts equal total costs, increasing effort over the equilibrium effort will result in financial losses for the industry. In fact, until the industry moves back to an equilibrium the real cost to the industry is the annual stream of net losses over time. Depending on the ex-vessel price, the numbers of years to adjust to an equilibrium, and the discount rate for evaluating net losses over time, real costs to industry could vary between $4.2 million and $27.0 million (see footnote 3).

To gauge the effect of Mexico's extended 200-mile jurisdiction on individual vessel owners, use is made of the survey data presented in Table 3. The landings-effort relationship indicates CPUE would decline from 325 pounds per unit to 310 pounds per unit. For the average vessel depicted in Table 3 this would mean 4.6 percent less landings. Holding prices and costs constant over the survey years, the average vessel's gross receipts would be reduced by approximately $2,800, $3,400, $3,600, and $4,700 for 1971, 1973, 1974, and 1975, respectively. It is only in 1971 that the representative vessels would have earned a profit.

SUMMARY AND CONCLUSIONS

A review of trends in catch-effort and price-cost relationships reveals the necessity for monitoring year-to-year changes in the fishery. Knowledge of these trends will indicate the status of the fishery in physical and economic terms and may pinpoint causes for its condition. The catch-effort and price-cost relationships can also be a basis for drawing up management plans by the newly created U.S. Fishery Management Councils.

Several points stand out in this review of the Gulf of Mexico shrimp fishery. First, changes in total effort were shown to affect landings. Expressed in a precise mathematical relationship, increases in the industry's total effort causes landings of shrimp to increase but at progressively lower rates. This has serious implications for policy makers and for private firms. For one, a vessel must expend greater efforts for marginal increases in catch; assuming fixed prices and per unit costs, increases in effort become less and less profitable. For the industry, this relationship has a compounding effect as the existing fleet increases total effort and/or new vessels enter the fishery.

An on-going survey of individual vessel costs also indicates items of major importance to the firm's operation. These items determine the ultimate profitability of the vessel and, in turn, its activity in the fishery. In the period 1971-75, total costs increased at a faster rate than revenue for the interviewed vessels, causing net losses in 1974 and 1975. Items showing the greatest increase included fuel, nets, interest, and depreciation.

The extension of Mexico's offshore fishing zone was analyzed using the effort-landings relationship derived earlier and the survey of costs and revenues. The extension would have adverse effects on the U.S. Gulf fleet, particularly the same type of vessels interviewed. Although the largest calculated loss from Mexico's policy amounts to 8 percent of the value of all shrimp landed, it would seem that the effects will largely be felt in Florida- and Texas-based vessels which do nearly all the fishing by U.S. Gulf vessels in Mexican waters. Finally, the estimates made of revenues reduced for fishing vessels by Mexico's policy is based on the assumption that the effort diverted from Mexican to U.S. water will be distributed uniformly through the year. However, as Figure 5 shows, that effort is very seasonal which will cause cash flow problems for vessel owners during the winter and early spring.

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MFR PAPER 1323

Estimating the Structure of Capacity Utilization in the Fishing Industry

KENNETH BALLARD and VITO BLOMO

INTRODUCTION

Research in industrial market structure has usually included capacity utilization behavior as a measure of market performance. Traditionally, this capacity has been used to gauge an industry's ability to absorb increased production without adding fixed resources. This includes, for example, some extraordinary situations such as World War II, or, as in fisheries, the extension of the U.S. coastal economic jurisdiction to 200 miles. Recently, however, there has been much research that has both expanded the definition of capacity behavior and improved the accuracy of analytical techniques. It has thus become possible to apply a capacity analysis in an expanded framework and to look at certain types of industry behavior that have been relatively neglected.

This paper discusses a consistent methodology for estimating the capacity utilization structure of an industry at various stages of processing. The empirical examples deal with the canned tuna and shrimp industries. These were chosen because they met two requirements: 1) Both have a volatile natural resource to harvest, and 2) both have a large and relatively stable processing sector.

Relating to the first point above, a major problem in analyzing an industry dependent upon the harvest of a scarce natural resource is that the output of the industry may not be directly related to the inputs of producing factors. For example, weather or fish migration patterns may have as much effect upon output in fisheries as the economic efforts of the industry. This uncertainty will, in turn, affect the functioning of capital and labor markets that determine the future economic potential. With few exceptions, this situation is almost entirely outside the realm of traditional economic analysis.

Secondly, a normally stable processing sector, but one that deals with an uncertain supply of inputs, will itself be affected. By adapting to a volatile set of conditions, the processing sector will tend to undercapitalize when it depends heavily on domestic supplies. This, in turn, creates an additional framework of uncertainty and possible bottlenecks affecting the harvesting sector.

This paper focuses on the relationship between the volatile structure of harvesting versus the processing sectors in fisheries. To accomplish this, the capacity utilization behavior of each is first examined independently and then combined into an integrated framework. The results concentrate primarily on the differential effects that a change in the utilization rate of one of the sectors would have on the overall economics of the industry.

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BACKGROUND

There have been recent theoretical and research advances in the study of capacity. Most have centered on definitional and analytical approaches to suit certain types of common problems.

This section contains a brief reveiw of the economic literature on capacity. Several interpretations of the term (Gang, 1974; Hertzberg et al., 1974; Christensen, 1975; Spielmann and Weeks, 1975) are contrasted starting with the traditional view of capacity defined as "the maximum amount of output that can be produced during a given period with existing plant and equipment." The phrase "can be produced" is the key to three primary interpretations discussed below.

Engineering Capacity

Engineering capacity refers specifically to the physical capabilities of the industry given a constant level of capital, skilled labor, and technology. The primary constraint on the amount that can be produced is the physical capacity of the existing plant and equipment as it operates around the clock, 7 days a week. There is no reference to the economic incentive to produce, to the relevant issues of capital-labor substitution, nor to the proportion of available time to which each of the factors is applied. The definition is thus more applicable to an "extraordinary demand" or stress situations and appears less relevant for the fishing industry. Moreover, this approach makes no provision for seasonal variability. In terms of measurement, this interpretation is mostly dependent upon extensive secondary data that are often lacking.

Economic Capacity—Microeconomic Approach

This refers to a program of production in which the profit-optimizing objective underlies the firm's decision-making process. Thus, under traditional microeconomic theory, maximum capacity will be the point at which all firms operate where marginal cost (MC) equals marginal revenue (MR). (This makes the standard assumption that short-run average cost is

less than or equal to marginal revenue.) In practice, firms try to minimize short-run average costs to maximize or approach maximum profit.

The economic theory for this measurement is irrefutable. The major limitation of this approach lies in its application to an imperfect world where factors other than short-run profit maximization may affect decision making. For example, if we consider cases of imperfect information, there will be a suboptimal production level, so at a given marginal revenue price the system will be operating at under 100 percent capacity (MR> MC). On the other hand, if we consider factors such as firms' reluctance to turn away customers in the desire for long-run profit maximization, then the system can operate at over 100 percent capacity (MC >MR). By definition, this economic capacity will always be below the engineering capacity. Finally, despite its economic bias, this approach would have limited applicability because it overlooks the highly institutional response of producers.

Economic Capacity—Macroeconomic Approach

This is defined in Klein and Summers (1966) as "the maximum sustainable level of output which the industry can attain within a very short time if the demand for its product were not a constraining factor, and when the industry is operating its existing stock of capital at its customary level of intensity." Taken on a macroeconomic level, the capacity utilization concept is now reduced to an empirical observation of how much producers have been willing to operate. There is no explicit reference to profit maximization, prices, or acceptable patterns of producer behavior. However, profit maximization is to some degree implied here because it is one of the major factors used by the industry to determine the maximum output.

Although theoretically weaker, this approach becomes effective largely where there are noneconomic factors, such as special producer-supplier relationships that affect the production process. With a large number of institutional factors, the inferential nature of the approach would tend to be more empirically accurate than the other techniques in defining the potential output levels.

CAPACITY ESTIMATION: THEORETICAL BACKGROUND

As with many other capacity studies, we have started by defining a production function that is Cobb-Douglas or first degree linear homogeneous. This is shown by

$$Q_t = A\, L_t^{\alpha} K_t^{\beta} T_t. \qquad (1)$$

Here, the output, Q_t, which can be produced in the current time period t, is determined by the available labor inputs, L_t, and capital inputs, K_t, and adjusted by a technology trend, T_t, and a constant or aligning coefficient, A.

Labor and capital inputs are adjusted in the equation by their marginal factor products, α and β. Because we have defined the system to be Cobb-Douglas, the relationship is considerably simplified, although the marginal factor products must sum to one:

$$\alpha+\beta=1. \qquad (2)$$

To adapt our methodology to the available data, a second contraining relationship has been added. This is shown by

$$Q_t=AV_tT_t, \qquad (3)$$

where $$V_t=L_t^{\alpha}K_t^{\beta}. \qquad (4)$$

In Equation (3), the labor and capital inputs have been combined into a single production unit, V_t. This structure in effect limits the factor inputs of labor and capital to roughly constant proportions. The inputs would always be applied in the same proportions when $\alpha=\beta$. For the analysis discussed in Results, we use the relationship of Equations (3) to (4) to circumvent the need for labor and capital data, as neither are adequately available in fisheries.

For the empirical analysis, we have modified Equation (3) into the final relationship:

$$\frac{Q_t}{V_t}=AT_t \qquad (3a)$$

We now have output per producing unit (productivity), which in fisheries is measurable, as a dependent variable, and a technology trend to determine the capacity potential.

To estimate the technology trend, we apply the peak-to-peak methodology discussed in Results. Here the level of technology in a particular time period, t, is determined by the average rate of change in productivity between peak years.

$$T_t = T_{t-m} + \left[\frac{\left(\frac{Q_{t+n}}{V_{t+n}}\right) - \left(\frac{Q_{t-m}}{V_{t-m}}\right)}{\left(\frac{n+m}{m}\right)}\right] \qquad (5)$$

Relative to a particular year, t, the values of n and m correspond to the length of time from the previous and following peak years.

RESULTS

The empirical methodology used in this paper is based upon the third or macroeconomic approach and uses published secondary data. Capacity utilization is estimated and based upon Equations (3a) and (5) in the previous section and demonstrated here using a graphical analysis. Here, annual productivity figures for one industry are plotted over time with a trend line to indicate the industry's maximum potential performance. The trend line is derived by connected peak years. Peaks are defined a posteriori: Years in which the industry was recognized as achieving the maximum sustainable output in the short run, i.e., 100 percent capacity. In practice, a peak year is often identified as of having a yield per producing unit that is significantly higher than both the preceding and following years. Percent capacity in any year is then calculated as the ratio of actual output per producing unit divided by the accompanying value from the trend line.

This section briefly discusses the results of the capacity calculations using

the methodology discussed in the section on Capacity Estimation. The results are divided into three parts: 1) The harvesting sector, dealing directly with the natural resource; 2) the processing sector, dealing with the canners; and 3) an example integrating both the harvesting and processing analyses showing how changes in capacity utilization in the production system affect prices.

Harvesting Sector

The level of resource availability and the producing facilities on existing vessels primarily determine the rate of capacity utilization in the harvesting sector. Common to many other industries, certain institutional factors dictate that nearly all of the harvesting facilities will be used during the season and that all the catch will be sold. In this sector, no current period market forces would regulate the harvesting production levels. The price level is the main short-run regulating mechanism. In the long-run, the investment in new capital is very upward flexible to meet changes in demand; however, because of long life and the very limited applicability of the vessels to other fisheries, the downward adjustment of the capital market is very slow.

Tropical Tuna

From 1960 through 1968, the tropical tuna fleet had a relatively high capacity utilization rate, and a large expansion effort started in the purse seine fleet. Since that time, tonnage has increased about 200 percent; landings have been increasing rapidly, but have not kept pace because of limited stocks and restrictions on yellowfin tuna catch in the Inter-American Tropical Tuna Association area. For the past several years, the capacity utilization rate has been steadily declining from 77 percent to a low of 43 percent in 1975 (Fig. 1).

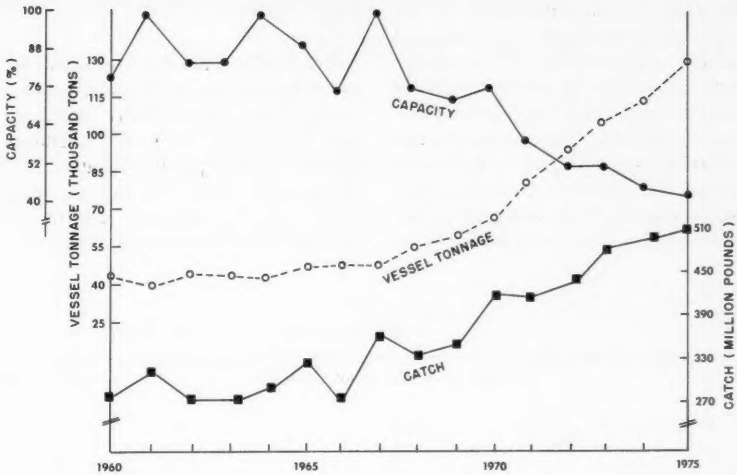

Figure 1.—Capacity rate, vessel tonnage, and catch of the U.S. tropical tuna harvesting sector, 1960-75.

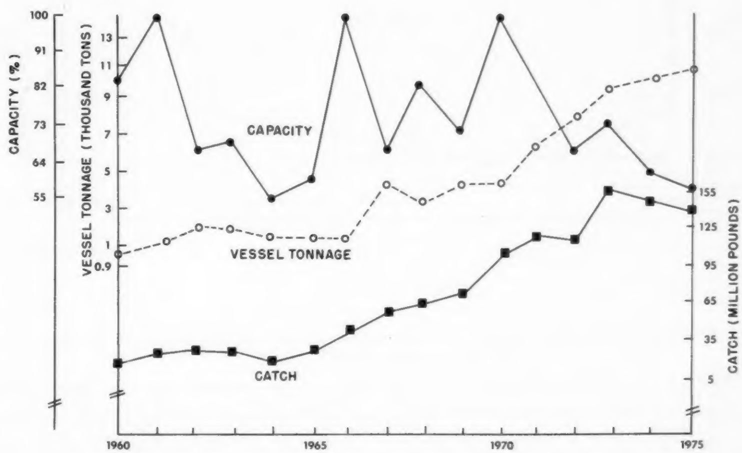

Figure 2.—Capacity rate, vessel tonnage, and catch of the Pacific shrimp harvesting sector, 1960-75.

Pacific Shrimp

Regular cycles of about 4 years characterize the capacity rate of the Pacific shrimp fishery. Although this cyclical fluctuation has been wide in the past (32-100 percent), the trend of the last 5 years suggests that swings in productivity may be moderating.

In earlier years, this fishery was not highly utilized. After 1966, however, because of increased demand for shrimp products, the fleet has been steadily expanding and catch has fully kept pace with this increase. As a result, productivity has been increasing and maintained at a consistently high level (Fig. 2).

Processing Sector

The main factor that determines the rate of capacity utilization in the processing sector is the fluctuation of the harvesting output. However, two constraints affect the current impact of the raw material availability. First, unlike the harvesting sector, there can be

major downward adjustments in the levels of both short- and long-run capacity and possibly use of nonfish food items. This is traditional in the food processing industry where both resource availability and seasonal factors necessitate a high degree of flexibility. Second, the industry uses cold storage and/or imports of raw materials to balance the levels of production over time.

Canned Tuna

Conjointly with the increased demand for canned tuna, domestic processors have significantly increased capacity since the early 1960's. During the 1960's, the capacity utilization rates are generally near 100 percent. Any excess capacity is mostly reflective of the start-up periods in new plants, i.e., the time between the actual building of the plant and when it becomes fully operational and efficient.

During the 1970's increases in demand for canned tuna started to taper somewhat. With the addition of several new plants and a lower than expected level of demand, the utilization rates have steadily declined over the 1972-75 period (Fig. 3).

Canned Shrimp

Until 1965, the demand for processed shrimp products was relatively stable with the production in the Pacific area at around 10 to 20 million pounds per year. The capacity utilization rate was normally under 50 percent. Since 1963 the demand and price for the small shrimp became exceptionally strong and processing increased dramatically to a peak of 117 million pounds in 1973. Because of these rapid increases in demand, the capacity utilization rate for the period after 1964 has hovered near or at 100 percent. For the most part, the plants that process shrimp are also used to process other fishery and agricultural commodities. The number of plants thus tends to be flexible, both upward and downward, by adjusting to current production requirements (Fig. 4).

Price-Capacity Utilization Relationships

This section quantifies the relationship between prices of the wholesale and ex-vessel levels with capacity utilization rates for the canned tuna and shrimp industries. The relationship is actually symbiotic, i.e., the level of capacity utilization depends, in part, on price; and the price level for the commodity depends, in part, on the capacity rate. Thus, changes in underlying economic forces that affect the price level can indicate a change in capacity utilization rate, and vice versa.

The basic estimating technique used was two-stage least squares taken from Cooper (1973). Each industry was modeled with four equations—two equations wherein price at the ex-vessel and wholesale levels are a function of several variables including capacity; and two equations wherein the capacity

Figure 3.—Capacity rate, number of processing plants, and production of the U.S. tropical tuna processing sector, 1960-75.

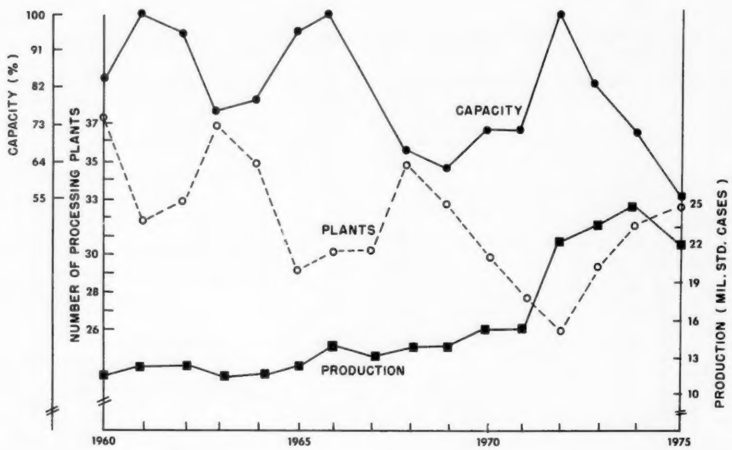

Figure 4.—Capacity rate, number of processing plants, and production of the U.S. Pacific shrimp processing sector, 1960-75.

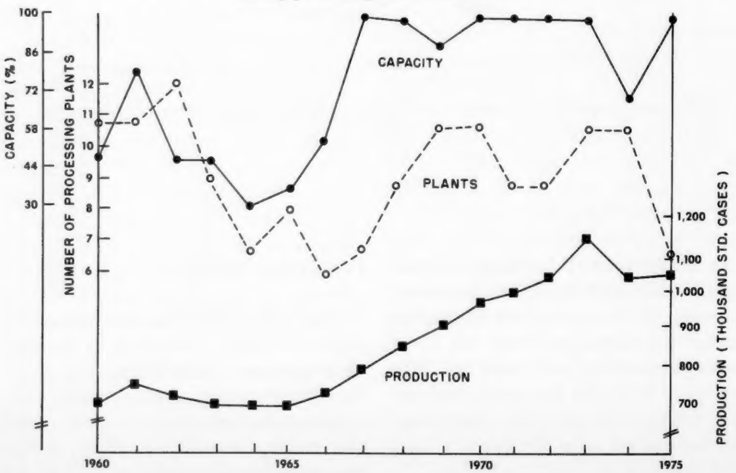

Table 1.—Estimates of tuna price and capacity utilization function coefficients, 1961-75.

Jointly determined variables[1]		Intercept value	A	B	D	Imports[2]	Dummy variable[3]	Wholesale price index (1967=100)	Time (linear)	GVT[4]	Processing plants	R^2	S.E.
Ex-vessel price $/lb	(A)	−0.0509		0.01293	0.0025	0.000004	−0.0102					0.969	0.009
				(18.53)	(1.26)	(0.92)	(−0.69)						
Wholesale price $/lb	(B)	6.884	10.8535		0.02414	0.00002		7.6432				0.998	0.182
			(3.22)		(3.21)	(1.09)		(9.17)					
Capacity rate in % ex-vessel level	(C)	90.7246		4.1228		−0.000007			−0.3379	−1.0356		0.061	3.762
				(1.44)		(−0.02)			(−0.63)	(−2.38)			
Capacity rate in % processing level	(D)	195.516		3.964		−0.0006			−2.341		−3.183	0.956	2.771
				(2.31)		(−2.33)			(3.13)		(−7.34)		

[1]Estimated with two-stage econometric method, autocorrelation adjusted by Cochrane-Orcutt technique; *t*-values in parentheses.
[2]Imports of light, chunk tuna, in millions of pounds.
[3]Zero-one variable for 1974-75.
[4]Gross vessel tonnage in Pacific tropical tuna fleet, in thousands of vessel-tons.

Table 2.—Estimates of shrimp price and capacity utilization function coefficients, 1961-75.

Jointly determined variables[1]		Intercept value	A	B	D	Imports[2]	Wholesale price index (1967=100)	Dummy variable[3]	Time (linear)	GVT[4]	Processing plants	R^2	S.E.
Ex-vessel price $/lb	(A)	−0.0725		0.0745	0.00033		0.095	−0.0154				0.966	0.007
				(2.32)	(0.97)		(5.05)	(−1.98)					
Wholesale price $/lb	(B)	0.777	5.7005		0.0027		−0.4322					0.837	0.066
			(3.07)		(1.87)		(−1.54)						
Capacity rate in % ex-vessel level	(C)	20.6111		483.355	0.2305	−0.00014			3.538	−18.476		0.875	4.699
				(3.22)	(1.29)	(−4.09)			(3.90)	(−6.77)			
Capacity rate in % processing level	(D)	61.0438		34.3227		−0.00014			0.783		−2.7179	0.940	6.094
				(1.48)		(−4.18)			(0.78)		(−1.91)		

[1]Estimated with two-stage econometric method, autocorrelation adjusted by Cochrane-Orcutt technique; *t*-values in parentheses.
[2]Imports of "Northern" borealis shrimp, in pounds.
[3]Zero-one variable for 1969-72.
[4]Gross vessel tonnage for the Pacific shrimp fleet, in thousand of vessel-tons.

utilization rates at the ex-vessel and wholesale levels are a function of several variables including price.

The primary relationship in both industry models is between prices and capacity utilization. We hypothesize that this relationship is positive with respect to the direction of change in one variable caused by a change in the other. We reason that because capacity is defined using the economic approach, i.e., using producer expectations of prices and costs, increases in capacity utilization must be an indication of a demand- pull movement in the market. Thus, increases in price, ceteris paribus, will cause an increase in capacity utilization, and vice versa. It is only until the capacity rate is over 100 percent that we would expect price to go in the opposite direction. However, the measurement process defines peak historical capacities as 100 percent.

The results of the two-stage econometric estimation are provided in Tables 1 and 2. Data were used from National Marine Fisheries Service and Bureau of Labor Statistics sources. All but one of the right-hand-side variables exhibited the expected sign in our hypothesized relationships. The explanatory power of the relations is quite high, and the standard errors in measuring the dependent variables are encouragingly small. In addition to the economic variables, we have included dummy variables in two equations where unexplainable abberations in the dependent variable were found.

Tuna Prices

The capacity rate at the processor level, as hypothesized, influences both price levels; marketing margins and input prices had a significant effect as well on ex-vessel and wholesale prices, respectively. The Wholesale Price Index (WPI) also influences wholesale prices greatly, reflecting overall costs of operation. Canned imports of tropical tuna had a very negligible impact on both prices; it was only 5 to 8 percent of the total supplies annually.

Tuna Capacity Utilization

As expected, wholesale tuna prices had the greatest effect on capacity utilization at the harvesting and processor levels. Increases in price increased the capacity utilization rate. Furthermore, increases in physical facilities—vessel tonnage and number of processing plants—decreased capacity at the harvesting and processor levels, respectively. The time trend variable at the processor level presumably reflects the rapid build-up in processing plants yet limits in the resource base. Again, imports have a negligible impact.

Shrimp Prices

Marketing margins and input prices, reflected by wholesale and ex-vessel prices, had the greatest effect on prices at the ex-vessel and wholesale levels, respectively. A positive coefficient on the WPI at the ex-vessel level reflects increased costs of fishing; a negative coefficient at the wholesale level may be owing to the relative stability of prices and an increasing WPI. Capacity utilization is seen to have a negligible impact on prices, possibly due to little variation in the data or stronger economic forces in other variables.

Shrimp Capacity Utilization

Wholesale shrimp prices primarily affected capacity utilization at the ex-vessel and processor levels; the relationship was positive, as hypothesized. As in tuna, increases in physical facilities had a negative impact on the utilization rate. Although the coefficients for imports were statistically significant at the 1 percent level, the magnitude of the coefficients was very small. A statistically significant coefficient for the time trend variable at the ex-vessel level reflects increased exploitation of the resource. At the processor level, facilities are often shared with fish and other food commodities.

CONCLUSIONS

We have attempted to build a conceptual framework to measure capacity utilization at various marketing levels for the canned shrimp and tuna fisheries. With this base, we then integrated our approach so that the effect of changes in capacity utilization on prices can be analyzed. Although this is a generalized methodology, results may vary from fishery to fishery because of the usually volatile nature of natural resource-based industries.

Results indicated that capacity utilization rates for the processing and ex-vessel levels for Pacific shrimp remained at relatively high levels. Factors include: 1) The resource was gradually exploited during the time period; 2) growth in physical facilities was stable. For the Pacific tropical tuna industry, capacity utilization had a generally negative trend, caused by the limitations in the resource and large increases in physical facilities. When capacity utilization was put into an integrated framework, prices at the ex-vessel and wholesale levels moved in the same direction as changes in capacity utilization.

ACKNOWLEDGMENTS

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Initial Assessment of Ocean Mining Called "Not Serious"

Measurements analyzed thus far show no serious impact upon the marine ecosystem from industry's first efforts to harvest manganese nodules from the Pacific Ocean floor, according to scientists with the National Oceanic and Atmospheric Administration (NOAA). A scientific team from the Commerce Department Agency's Pacific Marine Environmental Laboratory returned to Seattle, Wash., in June on board the NOAA ship *Oceanographer*, after several months of monitoring test mining in the Pacific.

Stressing the preliminary nature of their conclusions, Robert E. Burns, the Deep Ocean Mining Environmental Study project manager for NOAA, said the scientists found little persistent effect from mining operations conducted by the Ocean Management, Inc., vessel *Sedco 445*. He emphasized, however, there could be chronic long-term, low-level effects which have not yet been identified or studied. The *Sedco 445* was mining in an area 865 nautical miles (1,600 km) southeast of Hawaii, in water about 15,000 feet (5,000 m) deep.

The monitoring included samples and measurements taken along the sea floor—from which the mining collector lifts manganese nodules along with some sediments and small bottom-dwellers in vacuum cleaner fashion—and around the plume of sediments discharged by the mining ship at the surface, as well as in the water columns between the sea floor and the surface.

Comparisons were made between light and nutrient levels, and other factors in the discharge plumes and corresponding measurements of the undisturbed ecosystem outside the plume. The effect of the mining ship's collector on the sea floor was also observed with deep-sea cameras, and box cores were taken of the disturbed sediments to determine changes in the kind of life forms found there. These samples of life forms in and out of the plumes were collected for subsequent laboratory comparison.

Preliminary analysis of benthic plume data, the NOAA scientists report, indicates that this plume did not go upward far into the water column, rising no more than a few tens of meters above the bottom. However, the plume may increase in thickness with time and distance from the collector, Burns said.

No evidence was found of significant lateral spreading in the benthic plume, although there were tentative indications that the plume moved horizontally, carried on slowly moving, deep-water currents. Considerable current-meter data remains to be analyzed, however, before firm conclusions can be drawn regarding the movement of the benthic plume. The NOAA investigators also found evidence of a rather rapid resettling of disturbed material near the mining collector. This "repiling" of the disturbed material near its point of origin suggested that the benthic plume did not migrate over a broad area.

Surface plume data suggests that much of the particulate sediments discharged by the mining vessel at the surface settled out of the surface plume, and returned to the sea floor. Dissolved constituents in the surface plume could be detected for periods of a few hours; but neither particles nor chemical differences could be detected in plume water more than about 24 hours old. This may mean, according to Burns, that surface plume effects are transient, with no detectable difference between plume water and undisturbed water a day or two after mining.

One of the crucial questions that still must be answered, the researchers note, is whether discharged material accumulates at the pycnocline, a marked change in water density at about 180 feet (60 m), which separates the well-mixed surface waters from the denser waters of the deeper sea.

Another vital question is how this remote but important corner of the global ecosystem will be affected by not one, but fleets, of mining ships. Preliminary answers may come from further analysis of data obtained during this year's voyages.

The scientists plan to revisit the area periodically to assess the rate at which the ecosystem recovered from nodule mining disturbances. Results from this, and a more detailed analysis of monitoring activites this spring, will be published later in the year.

Domes, the Deep Ocean Mining Evironmental Study, began in 1975. The project is conducted by scientists from NOAA's Pacific Marine Environmental Laboratory, in Seattle, Wash., and is part of NOAA's Environmental Research Laboratories' Marine Eco-Systems Analysis Program.

The first phase of Domes involved a series of voyages to the tropical Pacific, where commercial mining may begin in the 1980's of the so-called "manganese nodules," potato-shaped accretions of metal that are rich in manganese, cobalt, nickel, and copper, and whose origins are uncertain. These early Domes studies established baselines for life and environment in the area before mining began, so that changes produced by mining could be compared to an undisturbed background, and also develop a first order capability for predicting potential environmental effects.

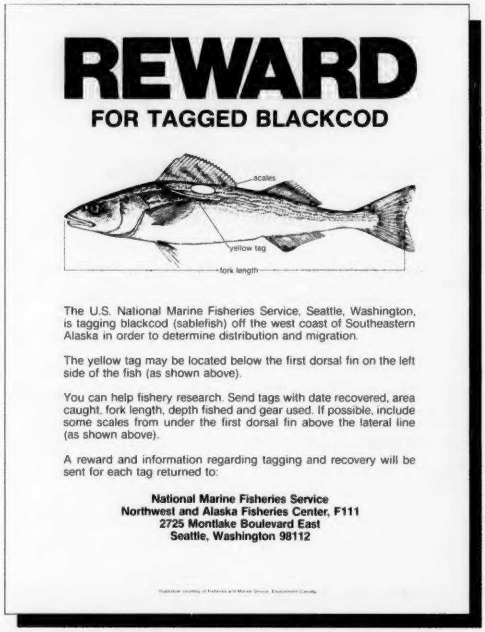
Phase II of Domes began with the monitoring operations this spring. Such monitoring will continue, to assess the ecological impacts of the various types of prototype mining apparatus soon to be tested by the deep-sea mining industry.

Sablefish Tagging Program Initiated

A 5-year sablefish, *Anoplopoma fimbria,* (also called blackcod) tagging program has been initiated by the National Marine Fisheries Service, an agency of the Commerce Department's National Oceanic and Atmospheric Administration.

Duane Rodman, biologist in charge of the program, said, "The tagging will be done off the west coast of Alaska with the primary goal of determining the distribution and migration of the species in Alaskan waters." Rodman added, "Since the fish migration may range as far south as California, it is important that fishermen along the entire west coast be informed of the effort."

The tag is a small yellow plastic tube and will be located beneath the first dorsal fin. A reward and the history of the fish will be sent to those returning a tag. Individuals finding a tagged fish are requested to send the tag, along with the date, location, method, and depth of capture, length, and a scale sample if possible to: National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Resource Assessment and Conservation Engineering Division, 2725 Montlake Boulevard East, Seattle, WA 98112.



Sablefish reward poster.

The eastern Gulf of Alaska has long been known to produce large amounts of sablefish. However, the lack of specific knowledge as to the movement of these fish has precluded an understanding of the effects of fishing and management policies in that region on sablefish fisheries in other areas. This project will provide information on the relationship between sablefish in the eastern Gulf of Alaska and those in inland waters of southeastern Alaska, the northeastern Gulf of Alaska, British Columbia, and other more distant areas.

For additional information on the program, contact Duane Rodman, Northwest and Alaska Fisheries Center, NMFS, NOAA, Seattle, WA 98112 (telephone 206-442-7796 or 442-7703).

Limit on Accidental Kill of Marine Mammals Halved for Japanese in Bering Sea

The number of sea lion, seals, and porpoises Japanese fishermen are allowed to catch accidentally while fishing in the Bering Sea has been slashed more than 50 percent for 1978, the National Oceanic and Atmospheric Administration (NOAA) has announced.

The Commerce Department agency's National Marine Fisheries Service (NMFS) has authorized an accidental catch of only 1,020 of the marine mammals, compared to an authorized catch of about 2,300 for 1977. During last year, the Japanese fishermen reported they actually caught fewer than 600 accidentally.

Under the Marine Mammal Protection Act of 1972, fishermen operating within the United States 200-mile Conservation Zone must request permits detailing the number of mammals which can be taken by accident. The mammals usually are caught in fishermen's nets while feeding in waters where fishing operations are being conducted. The Act requires that fishermen must make every attempt to release the animals unharmed when they are caught. Permits issued by NMFS in response to Japanese requests will limit the accidental catch to 1,000 sea lions, 9 seals, and 11 porpoises.

Commerce Exhibit Honors 75th Anniversary of the U.S. Canned Tuna Industry

The first in a projected series of special exhibitions honoring U.S. industries, held in the Commerce Depart-

ment in May, highlighted the U.S. tuna canning industry, Secretary of Commerce Juanita M. Kreps announced.

It was the first industry-oriented exhibit presented in the Department as part of the "Living Buildings" program sponsored by the General Services Administration. The U.S. Department of Commerce Building was designated as the Washington centerpiece for the program when it was started last year to help make federally owned public buildings more accessible and attractive to the public.

This year marks the 75th anniversary of the U.S. canned tuna industry. The official observance is being supported by associated businesses and labor unions, Congress, consumer groups, and government agencies, coordinated by the Tuna Research Foundation headquartered in Washington, D.C.

Administrator of Commerce's National Oceanic and Atmospheric Administration Richard A. Frank opened the tuna industry exhibit of historical photographs at ceremonies on 23 May. The photos were displayed in the south corridor adjacent to the auditorium located in the main Commerce building at 14th and Constitution Avenue, N.W.

Following the exhibit, the photographs as well as industrial equipment, artifacts, and old films, were donated to the Smithsonian Institution to become part of the collection at the National Museum of History and Technology.

Recreational Boating Deaths up; NOAA Tells of Safety Activities

The fatality rate in recreational boating accidents is on the increase after a downward trend during the last 4 years, says the National Oceanic and Atmospheric Administration (NOAA), which provides up-to-date nautical charts and weather information to millions of American boaters each year.

Citing U.S. Coast Guard statistics, NOAA said there were 6,815 boating accidents last year, involving 8,554 vessels, in which 1,312 persons lost their lives. This was an increase of 48 fatalities over the 1976 figure of 1,264, which was the lowest in 10 years. In 1975 there were 1,466 deaths, 1,446 in 1974, and 1,754 in 1973.

To promote boating safety and assist recreational boaters in obtaining more boat knowledge and skills, NOAA's activities include:

1) Publication of Notices to Mariners, informing boaters of critical changes affecting safe navigation.

2) Issuance of new editions of nautical charts by NOAA's National Ocean Survey.

3) Sponsorship of the National Chart Up-Dating Workshop for the U.S. Coast Guard Auxiliary, to give members a better knowledge for investigation and reporting chart deficiency items.

4) Conducting chart evaluation surveys to determine if presently charted items affecting safe navigation are still critical to boating safety. Controlled reconnaissance hydrographic surveys are also conducted in areas where possible uncharted hazards may exist.

5) Operation of NOAA Weather Radio to provide weather forecasts and warning to recreational boaters and others. On the air continuously, taped weather messages are repeated every 3-5 minutes, 24 hours a day, 7 days a week. They are updated usually every 2-3 hours, and revised also to meet fast-changing weather. Special receivers or tuners are required to receive the forecasts on 162.40, 162.475, and 162.55 megahertz.

6) Provision is made on NOAA Weather Radio of a variety of specialized weather information for boaters, fishermen, surfers, and others engaged in marine activities. River forecasts are given where flooding or waterway navigation are important.

7) "National Ocean Survey Publications for Safe Navigation," a free, six-panel folder describing various types of nautical charts, maps, and related publications, and how to order them; and "Nautical Chart 2 (So You Bought A Boat!)," a 44-page booklet with chapters on the nautical chart, use of fishing instruments for navigation, the radio, weather, compass, piloting, rules of the road, boat lights, the anchor, and charting products, have been published. Price is $1 each. Both publications are available from Distribution Division (C44), National Ocean Survey, Riverdale, MD 20840.

Coast Information Center Established in Michigan

A regional coastal information center for planners, managers, scientists, and the public will be established in Ann Arbor, Mich., at the offices of the Great Lakes Basin Commission and the Michigan Sea Grant Program. Funds for the center, in the form of a $50,000 grant, come jointly from three agencies of the Commerce Department's National Oceanic and Atmospheric Administration: the Office of Sea Grant, Office of Coastal Zone Management, and Environmental Data Service. An additional $25,600 has been pledged by the University of Michigan.

The Michigan center is in addition to similar centers in the Pacific Northwest and Northeast. The centers allow state and local agency personnel, coastal planners, legislators, environmentalists, and the general public to obtain information and guidance on coastal area subjects, including laws and zoning regulations, scientific data, and sources of publications.

A unique aspect of the Great Lakes center will be the regular exchange of information with Canadian Federal and Provincial Governments. Canadian representatives participate in Great Lakes programs and activities, and the Government is officially represented on the Great Lakes Basin Commision.

New Sea Grant Review Panel Members Named

Seven Americans who have distinguished themselves in fields related to oceanic studies, education, and public service have been named by Secretary of Commerce Juanita M. Kreps to membership on the National Sea Grant Review Panel. Five replace members of the 15-person panel whose terms have

expired, while the other two succeed members who have resigned.

Appointed to 3-year terms are Paul D. Triem, Vice President and General Manager, Umpqua Division, Bohemia Inc., Eugene, Oreg.; Lloyd N. Ferguson, Professor of Organic Chemistry, California State University, Los Angeles; Arturo Morales-Carrion, Executive Director, Puerto Rican Foundation for the Humanities, San Juan; Mary Lou Munts, State Representative, 76th Assembly District, Wisconsin; and Walter V. Yonker, Laboratory Director, National Food Processors Association, Seattle, Wash.

The other new members are Roy A. Young, Chancellor of the University of Nebraska in Lincoln, Nebr.; and Charles L. Drake, Chairman of the Department of Earth Sciences, Dartmouth College, Hanover, N.H.

Young will fill a 2-year term vacated by former U.S. Representative Charles A. Mosher, who resigned to accept a position as Executive Director for the House Committee on Science and Technology. Drake replaces George S. Benton, formerly Vice President of the Homewood Divisions of Johns Hopkins University, who has been named Associate Administrator, National Oceanic and Atmospheric Administration. Drake will serve a 1-year term.

Members whose terms have expired include Sanford S. Atwood, President, Emory University, Atlanta, Ga.; Werner A. Baum, Chancellor, University of Wisconsin, Milwaukee; Phillip Eisenberg, Chairman of the Executive Committee, Hydronautics, Inc., Washington, D.C.; Harold E. Lokken, Manager, Fishing Vessel Owners Association, Inc., Seattle, Wash.; and Harvey Weil, Senior Partner, Kleberg, Mobley, Lockett & Weil, Corpus Christi, Tex.

The panel serves in an advisory capacity, assisting the management of the Sea Grant program in the development of policies and programs in providing matching-fund grants to colleges and universities for research, education, and advisory services related to marine resource utilization. The Sea Grant program supports more than 600 projects at approximately 125 colleges and other institutions across the nation.

Anglers' Guide for U.S. Pacific Coast Published

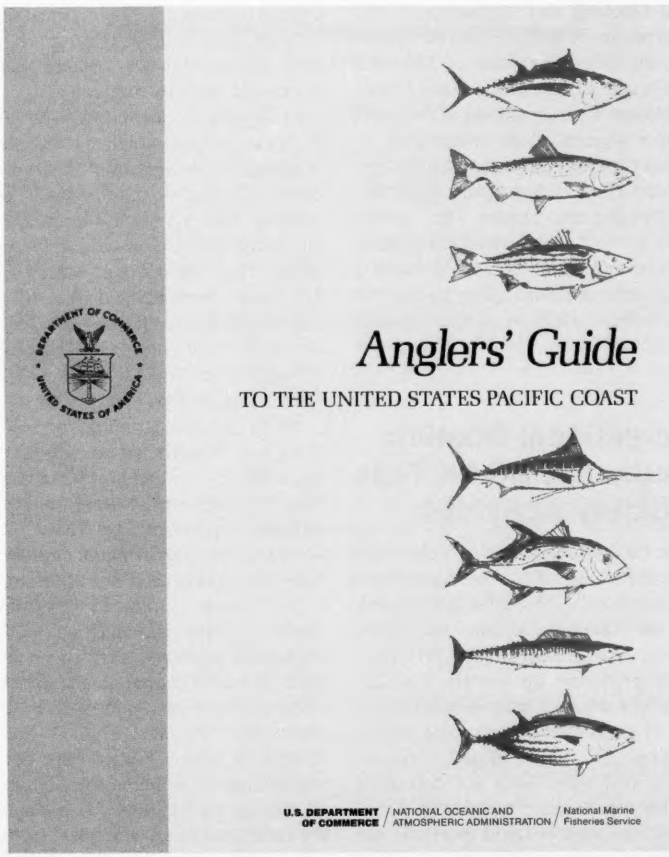
A guide which provides general sources of information on the more frequently fished areas and the species of fish that are commonly caught along the U.S. Pacific coast, Alaska, and some of the Pacific islands, has been published by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service.

Written by James L. Squire, Jr., and Susan E. Smith of the National Marine Fisheries Service, the "Anglers' Guide to the United States Pacific Coast" is arranged in five sections. Each contains a detailed series of coastline fishing charts that outline offshore, bay, and shoreline fishing grounds and gives locations of marine recreational charter and party boats, boat launching sites, fishing piers, skiff rentals, and jetty fishing sites.

Accompanying the charts is a general description of each fishing chart and the common game fish that are found in the area.

The guide also contains 237 illustrations with a description of the most commonly caught fish along the U.S. west coast and Pacific islands.

The guide may be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Stock Number 003-020-00113-1, cost $7.50. It is also available through local U.S. Government Printing Office bookstores.



Japan-Soviet Fishery Treaty Curtails Japanese Salmon Fishing

The Japanese salmon fishery in the northwest Pacific has been dealt a serious blow by the various new restrictions introduced in the 5-year Japan-Soviet Bilateral Fishery Cooperation Agreement which was signed in Moscow on 21 April 1978 between Soviet Fisheries Minister Alexander A. Ishkov and Japanese Agriculture and Forestry Minister Ichiro Nakagawa.

In the protocol to the Agreement governing Japanese catching of salmon in the northwest Pacific outside the Soviet 200-mile fishing zone, Japanese fishermen are allowed to catch a total of 42,500 t or 32.8 million fish in 1978, whichever is fulfilled first. The new salmon quota represents a drastic 31.5 percent cut from the 1977 quota of 62,000 t and a reduction of as much as 46.9 percent from the 80,000 t caught 2 years ago prior to the 200-mile zone declaration by the Soviet Union.

Of this total quota for 1978, catches allowed in open seas outside the Japanese and U.S. 200-mile zones adjacent to the Soviet 200-mile boundaries are limited to 28,000 t or 19.8 million fish. Species limitations are set to 4.3 million fish for chum salmon and 1.6 million fish for red salmon, with a 10 percent allowance each.

The recent Agreement has closed for salmon fishing a traditional fishing ground for Japanese motherships and middle-sized drift gillnet vessels in an area bounded by lat. 44°N, long. 170°E, and the Soviet and U.S. 200-mile zone boundaries. The fishing season for 1978 was set for a 3-month period from 1 May through 3 July, as compared to from 30 April through 10 August last year. The Agreement was to come into force following parliamentary ratification to replace the existing treaty which expired on 29 April this year. The agreements on salmon fishing as proclaimed in the protocol will remain in force until 31 December 1978.

The Soviet Union first proposed a total ban on salmon fishing in the international waters on the grounds of preserving river-born salmon resources in the northwest Pacific over which she claims parent-stream jurisdictional control. The Soviet Union later retracted this stand to propose that regulations governing salmon fishing be renegotiated on the basis of annual bilateral consultations. This proposal was accepted by Japan. In return for the fishing provilege, Japan has agreed to make a payment in goods into a "fishery cooperation fund" which in 1978 would total approximately ¥ 1,760 million (US$8 million at ¥220 = US$1).

The severe quota reduction in the new Japan-Soviet Bilateral Fishery Cooperation Agreement was expected to require a curtailment of Japanese salmon vessels by about 30 percent, which, occurring in the wake of a 20 percent curtailment last year, would bring the Japanese salmon fishing fleet to half of its strength only 2 years ago. The amount of compensation needed for this curtailment plan will total ¥50-78 billion, on the basis of the government contribution at ¥300-400 million/vessel plus contributions from the surviving vessel owners at ¥100 million/vessel. (Source: FFIR[1] 78-6.)

Mediterranean Bluefin Tuna Airlifted to Japan

This year's extremely strong demand for fresh high-grade tuna in Japan has revived a once-abandoned airlift of fresh bluefin tuna from the Mediterranean. Two earlier shipments which had arrived in Japan were quoted at the Tokyo Central Wholesale Market at prices ranging from a high of ¥4,400/kg (US$8.77/pound at ¥228 =US$1) to a low of ¥3,900/kg (US$7.75/pound).

The ex-vessel prices of fresh bluefin tuna at the landing ports in the Mediterranean are said to be around Fr. 10/pound (US$2.13/pound).

The cost of shipping from the Mediterranean is higher than from the east coasts of the United States and Canada, since the fish are transported first to Paris before being placed on a flight to Tokyo. The profitable threshold price of airlifted Mediterranean bluefin tuna is reported to be around ¥3,000/kg (US$5.98/pound). (Source: FFIR 78-7.)

North Korea Sets 7-Year Fishery Production Goals

North Korea (People's Republic of Korea) reportedly aims at increasing annual fishery production to 3.5 million metric tons by 1984, the ending year of the second 7-year economic development plan which it is launching this year. These are considered to be scaled down from the previously reported production goal of 5 million tons in the face of limited opportunities for fish landing in the foreign coastal waters.

Chief among the goals in the new economic plan are construction of 20,000-ton factory ship(s), refrigerated

[1]Foreign Fishery Information Releases are compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, CA 90731.

carrier vessel(s), and a series of 3,750-ton class trawlers equipped with modern gear, and development of fishery centers, refrigeration facilities, and processing plants capable of increasing the output of frozen products by 1.8 times, canned products by 3.1 times, and dried products by 1.7 times. Following the previous economic development plan between 1971 and 1975, North Korea's fishery production totaled 1.6 million metric tons in 1976. (Source: FFIR 78-4.)

Canada's Fishery Product Sales to Japan Increase

Canada's fishery product exports to Japan gained significantly in 1977 thanks largely to its 200-mile zone jurisdiction and the stability of its dollar, according to a dispatch from the JETRO (Japan External Trade Organization) office in Montreal. During the first 9 months of 1977, Canada's overall exports to Japan rose to $29,040,000, 4.7 times greater than the comparable 1976 period. During the same period in 1977, the exports from five eastern provinces, consisting mainly of squid, smelt, frozen tuna, and herring roe, totaled $6,690,000, 8.8 times greater than the 1976 period. (Source: FFIR 78-4.)

Geothermal Energy Runs Hokkaido Eel Facility

An eel farm utilizing geothermal heat from a hot spring to control the water temperature in a culture pond during the cold winter in Hokkaido, Japan, has reportedly succeeded in raising the elvers from an average size of 4 cm in length and 0.2 g in weight to an average 7 cm and 0.8 g over a period of 1 month. The farm is reportedly capable of maintaining the water temperature in the 400-m² culture pond at as high as 24°C (75.2°F) and the indoor humidity surrounding the pond at 80 percent during the coldest part of the winter, utilizing the heat from a nearby hot spring measuring about 50°C.

In March this year, approximately 60,000 elvers weighing about 10 kg in all were introduced in the pond at a water temperature of 12°C. The temperature was then raised 2°C each day until it reached 23°C, when the elvers were fed the first meal consisting of thread earthworm. The meal was changed later to a diet of proportioned nutrition and especially prepared ingredients. The loss by death by the end of the first month was only about 1 percent of the initial stock. About 500 kg of immature eels averaging about 30 cm in length and 50 g in weight were also reportedly undergoing a healthy growth in the geothermally heated pond. (Source: FFIR 78-6.)

Canada and Japan Settle on Herring Roe Prices

Canadian herring roe processors and Japanese trading firms reached an agreement earlier this year on herring roe prices for export to Japan in 1978. The prices settled for the roe extracted from fresh herring by brine curing were C$6.00/pound for No. 1 grade, C$5.00/pound for No. 2 grade, C$4.20/pound for No. 3 grade, C$2.30/pound for No. 4 grade, and C$1.30/pound for immature roe, FOB Canada. These prices are conditional depending upon the prices for the roe extracted from frozen herring by thawing, which are to be settled in a bidding in about a month. Should the bidding prices exceed the prices for the roe from fresh herring, these prices will be adjusted upward by adding 50 percent of the excesses. Last year's export prices, after adjustment, ended with C$5.42/pound for No. 1 grade. The delivery of Canadian herring roe to Japan was expected to begin in May.

Japan reportedly will import an estimated 12,500 metric tons (t) of herring roe in 1978. This includes about 10,800 t or about 86 percent from Canada, about 600 t or about 5 percent from the United States, about 400 t each from Mainland China and South Korea, and about 300 t from other countries.

The wholesale prices of herring roe at the Tokyo Central Wholesale Market as of 27 February were reported to be ¥5,400 to 5,500/kg (US$10.44-10.63/pound at ¥235=US$1) for extra large size, ¥5,300 to 5,400/kg (US$10.25-10.44/pound) for large size, ¥5,000 to 5,200/kg (US$9.67-10.05/pound) for medium size, and ¥4,500 to 4,700/kg (US$8.70-9.09/pound) for small size, up approximately 20 percent from the same period last year. The current domestic holdings are estimated to be between 300 and 500 t of roe and about 500 t of frozen herring at the processors level. (Source: FFIR 78-4.)

Soviet 1977 Coastal Salmon Catch Double 1976 Record

The 1977 coastal salmon catch by the Soviet Union totaled 139,364 metric tons (t), practically double the 69,723 t it caught in 1976, according to the data revealed by the Soviet delegation to the Japanese-Soviet fishery talks in Moscow on 13 March. This figure surpassed for the first time Japan's high-seas salmon catch for any single year. The Japanese Fishery Agency spokesman expressed surprise at the Soviet figure, and attributed the increased Soviet catch in 1977 to the rebounding fish resources and the drastic reduction in Japan's high-seas salmon quota in 1977. (Source: FFIR 78-5.)

U.S.S.R. salmon catch by species, 1971-77.

	Catch (t)				
Year	Red	Chum	Pink	Others	Total
1971	2,249	10,546	58,445	6,355	77,595
1972	952	5,112	20,428	4,121	30,613
1973	1,713	4,345	66,449	4,351	76,858
1974	1,103	7,058	31,981	5,718	45,860
1975	1,474	6,726	68,994	5,722	82,917
1976	1,128	9,789	53,272	5,534	69,723
1977	1,884	16,212	114,270	6,998	139,364

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 6, "A List of Common and Scientific Names of Fishes from the United States and Canada," third edition, 1970. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Citations

Title the list of references "Literature Citations" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10- inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 1107 N.E. 45th Street, Room 450, Seattle, WA 98105.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 100 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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